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GEMINI VIII

TECHNICAL DEBRIEFING (U)

March 21, 1966

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HOUSTON, TEXAS

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PREFACE

This preliminary transcript was made from voice tape recordings of the Gemini VIII flight crew debriefing conducted by Captain Schirra immediately after crew recovery, March 18, 1966.

A subsequent debriefing was conducted at the Crew Quarters, Cape Kennedy, Florida, by Mr. J. Van Bockel on March 19-20, 1966.

Although all material contained in this transcript has been rough edited, the urgent need for the preliminary transcript by mission analysis personnel precluded a thorough editorial review prior to its publication.

Note: The section covering the problem area encountered after docking and referred to as the Gemini VIII Self-debriefing is contained within Section 4.0, Orbital Operation.

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1.0 COUNTDOWN

1.1 Crew Insertion

Armstrong — Crew insertion was at T-115 minutes, which gave us more than adequate time to complete all required functions from the crew point of view. We had one discrepancy in the right hand harness.

Scott — Apparently, the coke fitting on the left side of the seat attachment had been filled up with some sort of glue or something, and I never did get to see it. It was behind me and Pete Conrad grabbed it and cleaned it out. I could see him working in the mirror -- he and Gunter, I guess. It took him a good 10 minutes to get that thing cleaned to where it would work, and then there was some question as to the pre-leveling on it and the spring -- whether or not it would work. Dick Gordon tried it out a couple of times and showed me how to put it on and take it off. I don't think there would have been any problem with it, once they did get it cleaned up, but had that, whatever was in it, been solid it might have cost us a launch.

Shepard — This could have been a serious problem. It

apparently was some kind of epoxy. Had it been harder it could have delayed the launch. It was hard on the surface only, according to Pete. It was soft underneath. It had not cured completely. It could have been serious.

Armstrong Two sequence tests involving gimbal monitoring were performed. There was, apparently, a repeat of the initial tests and we were not informed as to what was the reason for this repeat. It gave us some concern, that we may have some difficulties with the spacecraft/launch vehicle combination that we did not understand. The STC gave us periodic news concerning the status of the Agena launch and orbit, the fact that first its shroud was indicated to not be released and later that they had indications of good shroud release. It was very reassuring to get that information. The D-Rings for the ejection seats were unstowed by the suit technicians after completing the ECS and shoulder harness connections. This procedure worked well as it's very difficult, although not impossible, to reach the D-Ring stowage pins when the shoulder harnesses are in the locked positions. However, it leaves you in the cockpit a fairly

long time there with a loose D-Ring. Do you want to talk about the EVA visor stowage, Dave?

Scott — We'd decided during SLD to stow the EVA visor up behind the TV monitor and this worked out very well. It gave me quite a bit more room in the cockpit to move my head around, and once we got into orbit it was easy to unstow the EV visor. I'd recommend that for anybody as tall as myself, like the next bunch of guys.

Armstrong — The left-hand attitude indicator needles were referenced to rates and on low scale, and a small oscillation of the needle could be observed as the vehicle responded to wind and engine gimbaling. After the erector was lowered, we unstowed the mirrors and checked positioning of the mirrors to determine what the best location was for observing the ground as close as possible underneath the spacecraft, the purpose being to determine the best way to check if you were over land or over the water when coming down on the parachute prior to releasing the single point and going to the landing attitude. This appears to be a practical approach and was used at the

termination of the flight. I used a zipper pad in my suit for increased comfort during long periods on the pad and found it to be very useful and not objectionable at all.

1.2 Communications

Armstrong — All our communications checks were satisfactory, as planned. We felt we had good information concerning the status of our launch time, launch azimuth, and so forth. How about the update, Dave?

1.3 Launch Azimuth Update

Scott — The update came in right on time and the needles looked exactly like they were supposed to. All of them were nulled. There was no question that we had a good update, based on what we had seen during the SLD.

2.0 POWERED FLIGHT

2.1 Lift-Off

Armstrong — My impression was that engine ignition was pretty much as expected, but perhaps smoother, if anything. Lift-off occurred on time as expected, but was very definite. There was no question about lift-off and the time at which lift-off occurred, both from my feeling of emotion and also from the point of view of sound.

Scott — I agree with that. I think you could tell right away when the bolts went. I also thought that the transition from lift-off was smoother than I had expected--the buildup to the thrust.

2.2 Pitch and Roll Programs

Armstrong — The roll program started at 9 1/2 seconds and the roll program ran to 93 degrees instead of the 97 1/2 that we expected. The pitch program started on time. We noted some mild vibration at 20 to 40 seconds and then the vibration disappeared.

Scott — I could feel the pitch program when it started. Could you feel it, or were you--?

Armstrong — I think I could detect the increase in rates, no question about it on the gauges. I noted as we

accelerated that shingle on the nose was flapping in the breeze, and I understand that Dave had one flapping on his side, too.

Scott — Yes, I did. You could see it. It was a white one right up in the center of the right side.

2.3 Engine 1 Operation

Armstrong — We had no noticeable POGO.

Scott — I agree with that. None at all.

2.4 Staging

Armstrong — The staging was very smooth and we got a definite orange-red fireball that we went through just as reported by Wally on his flight. I felt that I could see an increase in window deposit at that time.

Scott — I thought the same thing. I think we were both watching for it and knew when it was supposed to occur. It was quite evident that we did fly through some. I could see the deposit on my window.

2.5 Second Stage Ignition and Guidance Initiate

Armstrong — The second stage ignition was just as we had expected. It was very smooth. Rate needles were very smooth with no oscillations in either axis. Guidance initiate came on time and was smooth. What did you observe in attitude, Dave?

2.6 Steering

Scott — The needles were as planned, I guess, except the pitch needle did not seem to have as much initial deflection as I expected. I expected a full scale from preflight discussions. It looked like about 4 degrees and guided into zero in a matter of 2 or 3 seconds; whereas, the yaw needle was as planned. It took about 4 seconds to come on in. Then, both of them were nulled. I guess the yaw needle was about a quarter of a degree off and they stayed that way the rest of the way. Very smooth.

2.7 System Status

Armstrong — Immediately after that, I asked you to check all spacecraft systems. What did you observe there, Dave?

Scott — Everything looked pretty good. I think the ECS O_2 pressure was a little high, but the rest of the systems looked nominal all the way around. Propellants and RSS were all good. The fuel cells were steady all the way through and I never did see a Delta P light during the whole launch phase.

2.8 SECO

Armstrong — We had a V/V_R of .8 at 5 minutes 7 seconds on my clock from the ground, and got SECO approximately on time.

3.0 INSERTION

3.1 Post SECO

Armstrong There were no residual rates at the time of SECO. The IVI's counted up to 4 aft, and I don't recall right now just what left-right and up-down were.

Scott When I looked over right after SECO, I copied down quickly 4 aft and 25 up on the IVI's before you made the burn. At that time, also, Address 72 was 25726 and Address 94 was minus 0015 before the burn.

3.2 SECO Plus 20 Seconds

Armstrong We started the separation burn just after 6 minutes and Dave didn't hear my first hack, so we burned in the scuppers for a couple of seconds and I gave him another hack and separated. There was a lot of debris flying around the spacecraft, generally in a forward direction, forward out in front of the spacecraft at this time, including some which appeared to be liquid spheres and some which appeared to be particles and some pieces of unknown shaped debris. We had decided before flight that we would not jettison the fairings immediately, but let the other parts of the separation sequence clear up before we jettisoned the fairings, so we could separate the two. And so, I

proceeded to roll upward to a heads-up position. By the way, our separation burn was 7 seconds, and I read 10 aft on the IVI's at the end of the sequence. After we burned into upright, I had 18 right on my IVI's.

Scott That's right, I copied that down as 10 aft and 18 right, and I had a 12 up in there somewhere, at some point.

Armstrong That's possible since we were slowly rolling and the IVI's were transferring from one axis to another. The surprising thing at the time was Dave reported his 72. What did you get for that number?

Scott For 72 I got 25748.

Armstrong Which was an increase of 22 feet per second, while we had only burned an indication of 6 feet per second on the IVI's. This was a little bit surprising to us, and it looked to us as though, if the 72 Address were correct, that we had a fairly high apogee. The initial report from the ground was a 155 apogee.

Scott I also got at that time for 94 a minus 0002, which means that changed significantly. I might as well throw in the others here: 52 was 0, Address 95 was minus 0010, and Address 89 was 03072. The orbit they

gave us at first was 85 by 155.

Armstrong We jettisoned the fairings at this time and had a strong moment. As I recall, it was yaw right and pitch up moment, associated with the fairing jettison.

Scott I could see them go by your window, too, by the way.

Armstrong I could watch both fairings go. Prior to this time I hadn't been able to see the scanner fairings, but by this time I had floated high enough up in the cockpit where I could see the edge of the scanner cover at the time it left, and watched both scanner cover and the nose faring depart the spacecraft. Since we pitched up slightly at the time, I lost the nose fairing immediately below the nose, and it disappeared. Of course, the fairing for the scanners disappeared out the left side of the window, almost immediately, also. I could see some sparks coming out, associated with the pyros that were releasing those fairings, apparently.

Armstrong After putting the spacecraft in PULSE and flying it to the horizon marks on the window and to zero yaw on the ball, I put the platform in CAGE SEF and then, upon stabilization, put it in SEF and PLATFORM Mode on the Primary Scanner. We noted that the spacecraft

then was hanging on the left-hand deadband of the platform with apparently all the thruster noise coming out of the right side. We could not detect any actuation of the thrusters on the left side, and it appeared that this was taking out the yawing moment from the water boiler. At that point, we continued with the Insertion Checklist. You have any comments on that Dave?

3.3 Insertion Checklist

Scott No, it was nominal. As far as I could see all the electrical readouts were well within tolerances and steady. The batteries looked good. There really wasn't much to it.

4.0 ORBITAL OPERATIONS

Armstrong The one thing that we had deleted, as a result of an agreement just prior to flight, was that we would not extend the HF antenna and do an HF check, since we'd just have to retract it again prior to docking. We left the platform aligning on Primary Scanners for 15 minutes, and at this time switched to the Secondary Scanner; the result there was the same as the Primary. We didn't see any significant change in spacecraft attitudes. It took about 1 1/2 minutes for the Secondary Scanner to lock up, and we still were riding on the left-hand deadband with the water boiler apparently still contributing to a yaw moment.

Scott I guess about this time we got the Nuclear Emulsion on. It was at 23 minutes, and they passed up our orbit as 87 by 147.

Armstrong Over Ascension we were given a GMT of lift-off, which turned out to be 16:41:02. They said they were standing by for a Comm Check and to switch to UHF No. 2. The reception on UHF No. 2 was not quite as good as on No. 1. We completed that check and went back to UHF No. 1. We were coming up over Africa, and I noted a bright red spot on the ground which

appeared to be a fire similar to a Texas oil well fire. I reported it to Dave. He couldn't see it out his window. Apparently, it was too far to the left.

Scott — I noted looking out the window I could see no horizon at all at that particular time. We also commented on the stars, and I had noted that at 30 minutes we could both see stars. Sunset was 34:08, so I guess we were seeing them before we crossed the terminator.

Armstrong — That's right. We could see stars, but had completely lost the horizon at this point. It is a very surprisingly long period of time when the horizon isn't really evident at all.

Scott — I also noted that at 38 minutes the thruster was still firing from the right side because I could see it. I could see the flash from the firing thruster out my window.

Armstrong — I could also see those thrusters firing through the right window. I couldn't see anything out the left window. In this case, it was darker looking out my window than it was looking out Dave's. Apparently, Dave's side was in the light; mine was pretty much in the shadow.

Scott — This was also about 4 minutes after sunset. There was a horizon visible out my window with which I

thought I could make measurements to within about a degree. It was a well-defined sort of a light colored haze or some sort of air-glow type horizon. There wasn't any color associated with it, but it was a definite horizon.

Armstrong I noted this also, and also noted that the cockpit lights had to be quite low for you to be able to identify the horizon boundary accurately. During the night passes I ran white lights on the left side at a low level. How about the right side, Dave?

Scott I ran red lights on the right side. I didn't even notice that you had white on. I just got the habit in the simulator of turning the red on.

Armstrong We turned the radiators to FLOW at 35 minutes. When did we activate the S-3?

Scott Number 1 at 40 minutes and 10 seconds.

Armstrong Turned the C-Beacons to COMMAND and the C-Adapter to CONTINUOUS, as called out at 40 minutes.

Scott I guess the next thing was the pass over Carnarvon where we got a GO for 16-1 after we called down the fuel cell amps and main bus voltage, all of which looked pretty good. I guess the No. 1 section was pulling more of the load than No. 2, but it was well

within tolerance and both of them were steady. It was pretty well distributed among the stacks.

Armstrong Yes, I noted a significant split between the two busses. I don't recall the numbers but it was very noticeable from my side.

Scott Yes, at the GO/NO GO over Carnarvon No. 1 main was 14.5 amps and No. 2 main was 8.0, so there was a significant difference between the two, but it was well within the 10 amp limit.

Armstrong Carnarvon gave us a GO on the water boiler, so we turned Evaporator to NORMAL. We started an Accelerometer Bias Check at this time. Dave set up the computer and pushed START COMP.

Scott Yes, we noticed that Carnarvon cut their summaries, I would say, about a minute and a half after we started the Bias Check, and I got the impression that they figured we were through at that time. It may have been a little early, although I'm not sure exactly how they were set up on the ground to do it. But, we were suppose to, as I understood it, go for 3 minutes. We continued on through a 3 minute period and at that time I read out of Address 80 a minus 0004, 81 00001, and 82 was minus 0004, which was a measure-

able quantity. I was surprised we had that much.

Armstrong During the 3 minute period the water boiler was still yawing us to some extent. I put in a couple of pulses to correct this and Dave reminded me that I shouldn't put in any pulses during the Accelerometer Bias Check. I agreed. Later it occurred to me that just the water boiler exhaust would probably be putting some bias into the accelerometers. Perhaps the pulsing, being in the opposite direction, would tend to cancel out that bias.

Scott I guess we also got a time hack there and the clocks were all running pretty good.

Armstrong At this point we started our Cockpit Configuration Control Sequence and removed our helmets, gloves, life vests and got out the light-weight headsets and started to stow the cockpit into the orbit configuration. Any comments on the stowage there, Dave?

Scott No, that seemed to go pretty well.

Armstrong I think Dave put on both neck and wrist dams immediately, and I waited until a later time to put on those neck dams.

Scott Yes, I think that might be an interesting point. I think you made a comment about the flow coming up to

cool you off. I noticed once I got my neck dam on that I was quite warm under my chin where the rubber was against the skin. I had to keep my head down in the books. Although it was cooler in the suit, I guess it was a little warmer outside up against the rubber of the dam.

Armstrong I noticed that your neck dam was ballooned up fairly high. How about the TV Monitor stowage? Did you unstow that at that time, Dave?

Scott I unstowed the TV Monitor and handed it up to you. It came out all right, as planned. I guess it took you awhile to get it in the orbit stowage location.

Armstrong I had a good bit of trouble in properly stowing that on top of the seat. I didn't seem to be able to get the elastic bands and hooks fastened into the appropriate fasteners on the top of the seats. Finally, I had to remove the velcro, take it down into my lap, and readjust the straps, since it turned out that they were not in the proper location on the viewing monitor to fit the fastenings. After readjusting them and putting them back up, I was able to satisfactorily stow it on top of the seat.

Scott I might also comment on the EVA visor which was stowed up behind the TV Monitor. I thought that was a good

place to stow it. It worked real well and it was secure throughout the launch and afterwards. It was easy to get out. It also enabled me to have a little bit more room inside the cockpit around my head without that extra bulk. That was a pretty good place to stow it.

Armstrong At this time we were coming up on the Hawaiian Islands. I had the Islands in sight, and could see Hawaii, Maui, and Molokai. Oahu and Kauai were under the clouds. As we passed over we did not point the spacecraft down to look at them, since we were essentially starting a platform alignment for our first Height Adjust Burn. We discussed the requirement of a platform alignment at this point since the burn was going to be only about 2 feet per second retrograde, and we were quite sure that the amount of misalignment in the platform at this time was insignificant. But, just for the drill of doing it, we went ahead and allowed the platform to be aligned at this point. I think we talked about at least doing a shorter one.

Scott We also checked out the computer and the transfer of 25, 26, and 27 into the IVI's, and that seemed to be working well.

Armstrong We were coming up on Baja, California, which was clear. I could see it out the left window very clearly from a long distance out. I observed Los Angeles Basin Area and a large number of aircraft contrails over that area. From orbit they were quite large and easily recognizable. I could see dry lake beds in the Los Angeles area. I tried to pick out Edwards, but wasn't actually certain that I could see the Edwards lake bed since we were fairly far south of that point.

Scott I thought it was interesting that the contrails were visible, too. I didn't expect to see them that readily.

Armstrong We observed the Texas Coast, coming up over Houston, but we were in an attitude for a burn so we really couldn't look down and see precisely where we crossed the coast. I didn't actually pick out any particular location on the Texas Coast that I recognized; although it was quite evident that the large crescent that runs from east-west down to north-south was part of the coastline we were coming over. We had our first burn coming up at what time, Dave?

Scott 1:34:37.

Armstrong It was a 2.9 retrograde burn, 5 seconds into the forward-firing thrusters. We already had the appropriate numbers in the computer and transferred them to the IVI's. We switched out and back in and reinserted them to take out any bias approximately a minute before burn. We made that burn in PLATFORM Mode. The burn was done on time, but we had difficulty removing the residuals. The residuals would vary. Each time we punched up 80, 81, or 82 it would come out with a different number. We had some discussion at that time about just what this meant.

Scott It seemed like it was taking quite awhile for the computer to process the accelerometer information for some reason or another. Within a matter of 4 seconds between readouts you would get .2 foot per second difference. For instance, after that burn we tried to null the residuals and ended up, finally, with a minus 0003 in 81 and a minus 0009 in 82, with 80 all zeros.

Armstrong We discussed this with the ground and Jim Lovell mentioned that it was probably the accelerometer bias and they were ready to send us a correction to the bias at this time. This they did. At this point we

started unpacking some food in preparation for the first meal. I unpacked Meal A from my left-hand wing box and started reconstituting some of the food and placing it around the cockpit on velcro. Dave, meanwhile, I think, was starting to unpack some of the things on his side.

Scott Right, same wing box. Pulled a meal out, reconstituted a couple, and stuck them up on the ceiling.

Armstrong At this time I think you made some comment about a heady feeling.

Scott Yes, I just noticed that there was some fullness in the head and asked if you felt the same thing. You said, "Yes" that it was very similar to what Frank Borman and Jim Lovell had mentioned in their debriefing.

Armstrong I hadn't really noticed it until you mentioned it to me, and then upon thinking about it, I thought, "Yes, that's probably the same thing that had been reported by the Gemini VII crew." It was certainly not a strong symptom.

Scott No, just a notice of something new and different.

Armstrong In preparation of the cockpit, you asked me to hand you the Flight Plan, so you could check and see where

we were. Upon checking, we found we had our Phase Adjust Burn coming up pretty soon, and were a little behind on aligning the platform for that burn. So, I immediately started aligning the platform at that point. Instead of doing this one in PLATFORM Mode, I did it manually in PULSE Mode to bring it in a little faster since we were a little bit behind.

Scott I think we finally did get into the burn on time without any particular problem. I made a note here that propellant quantity was 98 percent before the burn.

Armstrong I think just prior to this you had managed to get the sextant bracket and the sextant unstowed and installed on the window. Also, I noticed at that time that the ECS oxygen was still running on the high edge of the vent break--the high edge of the yellow band.

Scott I also noted here the quantities on ECS O_2 and the RSS. We had 70 percent for the ECS O_2, 90 percent on the Fuel Cell O_2, and off-scale on the H_2. It was sort of a record for D-3.

Armstrong We did the Phase Adjust Maneuver in RATE COMMAND Mode, since I wanted to have a chance to operate the RATE COMMAND Mode through a fairly long burn. We did that burn on time. It was 1 minute and 8 seconds

long, approximately. We had some trouble with the residuals again. It wasn't consistent. What did you observe on those, Dave?

Scott It seemed like we were still getting slow response to 80, 81, and 82. Finally, you worked on them, and got them down to 00001 on 80, minus 0001 on 81, and 00003 on 82.

Armstrong Even without inputs, we would seem to see residuals that would vary. It might be 2 the first time you punched up 82, then it would be 4 the next time you punched up 82. Next time it would be back to 2.

Scott You could almost take the residuals out by waiting until the proper time to punch it up. After that burn, I noted propellant quantity was 88 percent.

Armstrong A couple of comments about the food -- I reconstituted a package of chicken and gravy, I think it was, and gave it plenty of time to reconstitute. I'm sure it was half an hour, but with an adequate amount of water in it did not really reconstitute satisfactorily. It was still dry in spots and had not completely reconstituted, but I did finish that, and was using the fruit juices as sort of an incentive to keep up on the water. I finished up one of my fruit juices out of

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the first package and had the second one also reconstituted. I found that, when I had a little time, I could fill those bags up with water and keep them handy, and take a drink whenever I had a couple of minutes with nothing to do. We also had a package of brownies in the first meal and these cubes were stuck together. I couldn't take them apart without breaking the protective coating around the outside, and they were very crumbly on the inside. It was quite difficult to eat those things without getting crumbs around the cockpit. I resorted to keeping it sealed at all times and biting off a piece while it was inside the package, and then pulling it out with my teeth so I wouldn't lose the crumbs inside the cockpit.

Scott I remember you made the comment about the brownies being crumbly. I had a tuna salad package that I put in, I think, 4 ounces of water instead of 3, because it didn't look like it would all get into it. It sat there for about a half an hour, and it also was dry and not yet completely reconstituted. I also fixed a package of juice at that time. I think it was a good idea taking along a lot of those drinks. You could fix one up, stick it in the top, and when you had a chance, drink it to keep you up on the water.

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Armstrong We found all along that unless you really worked on it it was hard to find time for eating and drinking. The packaging situation and the time requirement to reconstitute the food are such that it's very difficult to complete a meal in anywhere close to a reasonable amount of time. We did make an effort to help the reconstituting process by kneeding the bags periodically. This, however, did not seem to fully do the trick.

Scott At some point in our training I remember hearing the comment that there was a new contract let for the food. This is the first food provided under that contract.

Armstrong I guess the most significant aspect of this period is the fact of the time requirements imposed by the food reconstitution and the lack of time available in the Flight Plan to complete this activity. It is unquestionably going to be a continuing problem on remaining Gemini Program flights because of their extremely busy activities throughout each day of their planned activity.

Scott Another thing on the food--I don't think you'd ever have time to put the germicide pills in it, you know,

if you were carrying out the rest of the mission. There's just not time to take care of a clean up after the food. I found that I ate mine and just wadded it up, and stuck it in the little garbage bag we'd set up.

Armstrong This was reported as a problem by the Gemini VI crew previously. We were not particularly concerned with this at this time because we had planned to dispose of all our first day's food wrappings and our throw-away bag during the EVA portion of the Flight Plan.

Scott I tried one package of cheese sandwiches, which seemed to work out pretty well. They are not bad and it is easy to eat them. They stimulate your thirst, which helps keep up the water.

Armstrong In this area, since Dave was so busy with taking care of the book work on the right side, I reconstituted some fruit juice for him when I had a few minutes free time, and it took him approximately an hour from that time before he had time to get around to drinking any of it. I might mention at this time that our ECS configuration was two-fan operation with the suit heat exchanges on MAX COOL. Of course, the spacecraft did not have a cabin heat exchange for the cabin fan.

We were certainly not cool in this configuration, but, on the other hand, neither were we particularly warm. It was a satisfactory temperature situation, in contrast to the problems of Gemini VI where they were unable to get a satisfactory temperature balance in the spacecraft. It appears as though we were working the Environmental Control System at its maximum cooling capacity for a situation where little physical work was required. Should more strenuous activity in the cockpit with regard to restowage and so forth be required, the system would probably be inadequate.

Scott — That's right. I agree with that. I guess the next thing we did was the plane change. There was a nominal platform alignment. I guess Neil did it about 15 minutes before the burn and then yawed 90 degrees right to south. We had a 26.2 Delta V at 02:45:50. Residuals at the end of that burn were all zeros for 80 and 81, and 00003 for 82. I think we still had the problem of something unusual in the residuals.

Armstrong — As I remember, on that particular one we took out some of the 0003 and punched it up again and still got 0003. So, we decided we would continue with that.

We did not have celestial fix points to use as a backup for these burns and probably feel it would have been an advantage to have it available.

Scott Yes, I think they could add that to the maneuver update with one more word.

Armstrong Right.

Scott Let's see, after the burn you got the optical sight out.

Armstrong That is correct. I was pleased to see that it was operative. The optical sight, of course, would be useful on the celestial fix backup type burns. Coming by Hawaii at about three hours, there was no mention of an additional height adjustment so we assumed that it was not going to be required. Upon arriving at Guaymas, I believe, we got word from Houston that a burn would be required at 03:03:41. As we recall, we got the information on this burn just a minute or so prior to the time of the burn, which gave us a very little time to reorient the spacecraft into burn attitude, and no time whatsoever to align the platform. We did make the burn on time, but it should be a procedure that is to be avoided since the crew in this situation is probably involved in activities at the

time that would preclude the success of a quick reaction type maneuver such as this particular type.

Scott And one thing on that -- you made the burn based on a Delta t. We never had a chance to go into the computer and set it up on the IVI's; therefore, we had no chance to take any residuals out. So, it was sort of a pretty quick loose burn. We had been paying significant attention to all the other burns and taking out tenths of feet per second. We just punched in 2 feet per second without much preparation.

Armstrong At this time it was our plan to send a command to the Agena for the acquisition lights on; however, we did not have a radar lockon at this time, so it was not possible. They indicated that the command had been sent from the ground and a MAP was received. Subsequent to passing Texas, we reported intermittent flickering of the radar lockon light. We reported a solid lock at 179 nautical miles range, after which we initiated the Rendezvous Test.

Scott We expected to get somewhat less than the optimum 248 nautical mile range for our particular radar configuration. They had actually guaranteed a lock-on at 185, so that was really pretty close. Not having a

lock on until this point in time prevented us from getting a complete radar test, this Rendezvous Test on the radar. But, in looking back at it, I'm not sure that's really too significant a test anyway, because you get it during the period from NSR to TPI. You get essentially the same kind of thing; although, it would be nice to know if you were having any problems earlier. We just barely got 8 data points before we had the NSR burn, which wasn't too significant except to be able to see that it was calculating range rate in an acceptable trend.

Scott At this point, too, we also had a fuel cell purge, the first one, and it went real well. As I remember, there was no Delta P light on the H_2 on Section 1, but we did get a Delta P light on the Section 2 H_2 purge. During the H_2 purge the Delta P meter went from .675 to .76 on Section 1 and .70 on Section 2, and during the O_2 purge it went to .65 on Section 1 and .65 on Section 2. So, they were pretty well nominal Delta P's.

Armstrong In approaching the NSR burn, we punched up START COMP after inserting the numbers and got a lot of non-understandable numbers in the IVI's, which apparently

were a result of something being stuck in from the Radar Rendezvous Test. So I asked Dave to reinsert the numbers. He did. We cycled the Computer Mode Switch and pushed START COMP again, and this time got the correct numbers. But, in going through that sequence we missed our time for the NSR burn.

Scott — I think I had put in, prior to the Rendezvous Test, the proper numbers in 25, 26, 27 and then when we tried it at the NSR burn time we got these strange numbers. I reinserted the same updated numbers as I had before and they came up all right the second time.

Armstrong — What were those numbers?

Scott — 25 was 00570, 26 was 00224 and 27 was all zeros.

Armstrong — I remember that was a 61.6 feet per second burn.

Scott — Yes. That's right. Our burn time was to have been 03:47:35 and we actually burned at 03:48:11.

Armstrong — So it was about 45 seconds late on burn time there.

Scott — I have a note here that after the burn we had 75 percent on the PQI.

Armstrong — Subsequent to NSR we went into RENDEZVOUS Mode at 5:40. I think we had just missed the 4-minute point and decided to wait until the next data point, 5:40.

Scott — The reason, I believe, that we missed that was

because of our residual problem again, trying to get those residuals out. We spent a lot of time trying to make sure we had a good NSR. I recorded that we got Address 80 down to 00001, 81 all zeros, and 82 was 00003. As I remember, again it took us quite a bit of time.

Armstrong As best I remember it was Address 82 that gave us more trouble than the others. It was always the one that we had difficulty in zeroing, at least to a greater extent than 80 and 81.

Scott Then, at that point, we switched over to the Rendezvous Book and picked up the readouts every 100 seconds on the angle, range, and range rate. It might be noted here that you weren't particularly trying to maintain an accurate boresight because at this time it was really not very meaningful. And so, some of the angles that we may have passed down to the ground may have been confusing to them. We weren't really trying to null them because there wasn't any particular need in it at this time.

Armstrong I might mention here that, contrary to the experience on Gemini VI, at this range the needles appeared to be quite steady.

Scott We checked the computer addresses and they were as we had been told the day before the flight. I inserted into Address 83 and 93 the proper values. I inserted 13000 for 83 and 04820 for 93. Up until the day before the flight there had been some question as to the other addresses, particularly Address 24, one over the reciprocal of the aft firing thruster acceleration. We had planned, up until the day before the flight, to have value 12690, but we were informed at the last minute it was 13130, which had been inserted in the computer and verified as being correct at that time. I think the day before the flight is a little late to get that value, because had I read 13130 out of that, based on the values I had on the Rendezvous Charts I would have reinserted 12690.

Armstrong It appeared to me that as we proceeded in at a slow rate of catch up, the IVI readings of V_T were not always consistent in that sometimes they increased rather than decreased. Looking at the numbers here, I see a case where we have this order: 421, 373, 389, 374. Here is one where we had 289, 272, 289, 263. I am not sure what the significance of these particular numbers are. I think we had one similar situation

pretty late in the flight, but I wasn't really concerned that it indicated improper computation, but rather, that there might have been some sporadic radar data input that created this particular situation.

Scott — Some of the numbers on the range rate were not consistent either. For instance, we ran 154, 151, 152, 149, 151, 152, which should have all been around 156. That may or may not be of any significance.

Armstrong — This, however, would agree with being a little bit high, and not having quite as much Delta h as we had planned on.

Scott — I don't mean the magnitude but the variation.

Armstrong — Oh, just the oscillation in the values. Yes, there was some oscillation in the Theta value, too, but this could be attributed to the accuracy of the tracking.

Scott — How about the visual on the Agena? When was the first time that you mentioned it?

Armstrong — We have that data on the voice tape, I'm quite sure. As I recall, we had our first visual contact at 76 nautical miles. We were in daylight at the time, and I reported seeing an object in the sky close to boresight. Shortly thereafter, I noted another light

object, equally bright, also very near the boresight. So, I turned the brightness of the optical sight down a little bit, looked very carefully, and observed 4 or 5 separate objects in the vicinity of the boresight. These objects, however, appeared to be diverging from each other to some extent, and the second bright object may have been a planet, since it was moving in an upward direction across the optical sight. It didn't appear to me at the time to actually have an orbital rate; however, it may have had a 4 degree per minute orbital rate. I did not time its progress across the optical sight to check that. When we were at approximately 55 miles range, or so, it was very clear that there was only one object remaining in the field of view of the optical sight, which we had correctly interpreted as being the Agena.

Scott I noted that I had a visual on the Agena at 56 miles. Neil had the acq lights about 14 minutes after NSR, at 45.5 miles, which was still about 10 minutes before official sunset. They had given us official sunset at 05:37 elapsed time, and this would have been about 05:27 that Neil saw the acq lights.

Armstrong I agree with that. The optical sight and the radar

needles agreed as to boresight within approximately half a degree in pitch and yaw. With the radar needles aligned on the radar boresight, the target could be observed in the optical sight 1/2 degree to the right and 1/2 degree above the centerline of the optical sight, in the upper right-hand quadrant of the optical sight. This optical sight had characteristics similar to those reported on Gemini VI, in that several degrees of boresight error could be introduced in yaw by improper tightening of the mounting lug screws for the sight. However, checks before flight had indicated that this was repeatable and that if you tightened the lug screws down as tight as you could with the fingers they would return to approximately the same position. We didn't know that it would really agree with radar boresight, or was indeed the structural boresight of the spacecraft. We tightened it fingertight as best we could.

Armstrong It was very obvious when we lost contact with the Agena by means of reflected sunlight. It was an almost instantaneous disappearance of the target. However, it was our impression that this disappearance actually occurred prior to spacecraft sunset. Indeed, we later

picked up the acquisition lights at a distance of 45 miles, when we both pretty well agreed that we actually were not in full darkness. We can't fully explain just precisely what happened here with respect to lighting and a more careful analysis of the sunrise and sunset times will probably be required to validate when the Agena was visible in reflected sunlight and when it was visible by means of acquisition lights. We had visual track on the flashing lights for some time prior to TPI, probably an adequate time to perform the optical track for a backup TPI calculation. However, the brightness was equivalent to approximately a 6 magnitude star and prevented you from looking back and forth, out the window and into the cockpit, without losing your optical track. So, were you to be tracking visually through the window, you would have to restrict yourself completely to out-the-window vision during the tracking period. This type tracking requires the optical sight to be adjusted to its very dimmest value. At approximately this range the radar angle data appeared to be more spongy than previously. This was evidenced by a variation in the boresight of the radar and the optical sight. The boresight would vary as

much as several degrees in somewhat of a random fashion. Since, however, the optical tracking required close concentration out the window, tracking with radar boresight was selected during this time period. This type of tracking resulted in some variation in the angle data. This radar sponginess was evident from approximately 45 miles out until perhaps 25 miles out, before, during, and subsequent to the transfer maneuver. This aspect of the rendezvous portion of the flight will be discussed in more detail in a separate part of the debriefing.

Scott We knew from our polar plot that we were riding somewhat higher than nominal. In other words, the Delta h between the Agena orbit and our orbit was something on the order of about 13 1/2 miles instead of 15. Therefore, we knew that we would probably have a lower LOS Delta V at TPI. The ground update was passed to us 32 feet per second forward .7 up, 5.7 left. The solution we received from the closed loop was 25 feet per second forward, 3 up, and 8 left, which agreed with what we had expected to receive based on our relative position. The backup solution gave us 25 feet per second forward, which is the

same as the closed loop, but it gave us 25 feet per second down, rather than the 3 up the closed loop gave us. We'll have to look into it to find out why, but I believe this is probably due to the sponginess of the radar needles and the inaccuracy of the angular at this point. The backup solution is basing this one correction on just 2 data points, and since the spacecraft was somewhat higher than nominal orbit, rather than predict on it to the final braking phase. So, it all looked reasonably correct to take the closed loop solution. Comparing times -- our initiation time was 26:10 after the NSR. The ground-based initiation time was 25:38, so we were reasonably close to the predicted burn time. We selected to take the closed loop solution at that time and burned on the Comp light.

Armstrong I would agree. After we got the second solution I asked Dave again what the plot looked like. We could see that this large normal to the line-of-sight correction that was indicated was not substantiated as some sort of relative ellipticity on the plot, and it was attributed to spongy radar angular information giving erroneous information for the three TPI calculations.

Had we used the optical sight in this region for these calculations, I feel reasonably sure that we would have gotten a much closer agreement between the three independent computations.

Scott I might also add that the ground-based information for the range at Point D, as we call it, was 32.5 miles, and our actual range, based on the backup solution and following through the closed loop, was 32.46. So, we were pretty close to the ground-predicted range; although, the range rate differed by approximately 4 feet per second. We were 4 feet per second slower than the ground predicted we would be. Another basis on which we selected closed loop at the time we did was the decrease in the magnitude of V Total which came up in the IVI's every 100 seconds, and it slowly decreased down to 69 feet per second at Point B, which was one point prior to the acceptance of the closed loop solution. So, this indicated that we were approaching an optimum PTI time.

Armstrong That was confused a little bit. There was one bad V Total reading, just 3 or 4 points before that, which confused us a little bit. It went down to 89 and back up to 93, and we were concerned that we

might have passed the optimum transfer time, but the next solution came out 72.

Scott And then 69, so we were fairly certain we were coming into the right time.

Armstrong We had planned on doing a platform align at an elevation angle of 9 degrees; however, we did not actually start until approximately 10 degrees, since our closing rate was a little slower due to our reduced height elevation. However, I felt we had a little more than the 10 minutes that was alloted for alignment starting at 10 degrees and 10 minutes. I initiated the alignment at approximately 55 or 56 minutes after NSR and we had a good 13 minutes of alignment time. The alignment was done in PULSE Mode so as to ensure a very good alignment with the time available. At the same time Dave was recording the sine of radar elevation angles out of computer so we could keep track of the thing not getting so high that we wouldn't have enough computation points left prior to transfer.

Scott I think this is an advantage of this particular math flow, enabling you to keep track of your elevation even though you are aligning. So you aligned

up to some time past 1 hour and 9 minutes after NSR.

Armstrong The transfer was initiated at 26:10, which was also the time that the Comp Light came on -- the correct time for the Comp Light to come on -- in closed loop.

Scott I have written here that you burned at 26:36.

Armstrong There may have been some small delay between the Comp Light coming on and the initiation of transfer, but it was not a significant time delay. No further platform aligns were accomplished after the one preceding TPI. Do you want to go ahead with the first correction?

Scott We calculated all 4 backup corrections and each time chose closed loop of the two. We did not burn any backup corrections. The first one was 4.5 feet per second aft and 10 feet per second down, based on the angular data between 1 and 4 minutes.

Armstrong This measurement, I felt, was still influenced by the spongy radar angular information and I was reluctant to put much faith in that particular data at that time. Subsequent to the first correction, however, the radar angular information seemed to steady out and the boresight agreed quite closely with the optical tracking. I feel that the subsequent corrections

probably quite good.

Scott This agrees in trend with the TPI because we had a big down correction in the first backup solution and a big down correction for the TPI that didn't look too right. I think you mentioned before that the sponginess started disappearing somewhere around 25 miles and that is just about the right time. For the second correction the backup solution provided 4 feet per second forward and 2.5 feet per second up. The closed loop came out with 12 feet per second forward, 6 up and 1 right. We burned the closed loop. The third correction on the backup charts came out with 3 aft and 2.5 up and we didn't burn that one, sticking with the closed loop. The fourth correction had 4 forward with the closed loop, 7 up and 5 right. The backup solution said 1 aft and 4 up and Neil burned the closed loop. After that burn, which was the second midcourse burn, we had 65 percent remaining on the propellant quantity gauge.

Armstrong After the completion of the 34-degree correction, the line of sight rates appeared to be neglible. The target was, for all practical purposes, fixed with

respect to the star background. As the Agena appeared in daylight shortly thereafter, it was recognizable immediately as a cylindrical shape and the star background very quickly disappeared.

Schirra This was before braking?

Armstrong Yes, this is prior to any braking actually being initiated. At the time of moving into daylight an extremely large number of particles was noted drifting aft, or rearward across the nose of the spacecraft, very similar to those reported on the Gemini VI flight. At the initiation of braking, the platform indicated that we were on approximately the 120-degree line and during the braking phase we drifted aft back through the vertical until we were slightly behind the target during the final phase. We had observed an "out-of-plane" developing during the early part of the phase immediately subsequent to transfer. This out-of-plane drift continued and no significant effort was made to stop this drift until during the braking phase. Then, a fairly significant lateral braking was required to arrest the line of sight rates.

Scott I might add that at one point I did take a quick look through the sextant to see if it would have been practical, without the radar ranging, to have used that for the braking within about 10,000 to 12,000 feet.

Because of the cylindrical shape and our relative position to the Agena I think it would have worked very well. When we got inside of two miles there, we had left the charts, essentially. We had made up a braking chart using the sextant to superimpose positions of the two images with angular distance between the two. Although we didn't use it, I think it would be practical to use it in an optical rendezvous type situation.

Schirra You could have judged 3,000 feet?

Scott Well, there is a schedule set-up here of angular data read out by the sextant versus range and you can compute the time between two angle readouts and therefore get the range rate. I think it would have worked pretty well.

Armstrong Our preflight planning had assumed braking to 40 feet per second at approximately 15,000 feet, and, as I recall, we were a little bit hot and actually kept 40 feet per second until something like 12,000 feet. Do you have that data recorded?

Scott Right, at 1.7 miles you were still 44 feet per second, and at 1.35 miles you were 39 feet per second, but it seemed pretty smooth to me as you

came in.

Armstrong Since the line of sight rates were not at all high we could afford to approach at a relatively high velocity, and we were interested in arriving at the target at the earliest possible time since we were somewhat late at transfer and we had a limited amount of daylight remaining for station-keeping. We wanted to take maximum advantage of that remaining time prior to the planned docking at or around the RKV.

Scott You finally ended up at about 150 feet at 42 minutes after the TPI, and propellant quantity at that time was 55 percent.

Armstrong There were no velocity changes made between the 34-degree correction and the initiation of braking.

Scott I had noted that you started your braking manuever at 28 minutes, which was 1.7 miles out, and you were at 44 feet per second. You applied 8 feet per second aft. Then at 30.5 minutes, you made another braking manuever and the IVI's read 17 aft and 1 down. At about 32 minutes, you applied another manuever and I had 25 aft. At 33 minutes, you got down to 15 feet per second, you were 2800 feet out, and the IVI

read 31 aft. At 35 minutes, you were at about 1700 feet out, 7 feet per second, and the IVI's read 31 aft, 10 right and 8 up. Then, at 37 minutes, at a range of 900 feet and 5 feet per second, you had 12 aft, 18 right, and 28 up. The last one that I had recorded was at 40 minutes. You were 240 feet, 5 feet per second, and the IVI's read 18 aft, 12 right, and 35 up. The next one was station-keeping at 150 feet at about 42 minutes.

Armstrong Station-keeping was performed in PULSE, RATE COMMAND, and PLATFORM Modes. As was reported previously from the Gemini VI flight, the PULSE Mode was adequate for station-keeping and, as long as the manuevering thrusters were operated for short periods only, no intolerable moments were created that could not be handled with the PULSE Mode. The PLATFORM Mode was a very good mode for station-keeping. It required very little attention. A platform alignment was conducted while station-keeping for approximately 10 to 15 minutes, during which time small manuevering thruster usage was utilized to maintain position with respect to the Agena. That alignment was done BEF. The

station-keeping range was generally 50 to 75 feet. At this range the Status Display Panel of the Agena was impossible to read in daylight from both lights and gauges. However, with the telescopic feature of the sextant, Dave was able to read all of the lights, but was unable to read the gauges on the Status Display Panel.

Scott I might add here that the most difficult one to read was the Dock Light. It was hard to see whether or not that was really green. The others were fairly easy with the sextant. We couldn't read the attitude gas, the PPS, and SPS gas remaining until we got in and rigidized. Even then it was difficult to read them because the glass had some sort of film over it, or it was smeared over the dials. It was very hard to read with the sun reflecting off on it. The sextant was 6 power, and I guess we could read it out to 50 to 70 feet away.

Armstrong The sextant used was the miniature, hand-held Ilon. At this time we prepared the Agena for the docking maneuver. The Agena appeared to be extremely stable. There were no noticeable motions in Flight Control Mode 1 that could be observed, but we

proceeded with the procedures outlined in the Flight Plan to convert the system to Flight Control Mode VI for the first docking. The target docking adapter was approached and the spacecraft was stopped at a distance of 3 to 4 feet out from the TDA in order to look closely at the Status Display Panel, the configuration of the cone in the unrigidized configuration, the condition of the latches, and so on. Upon determining that the overall TDA configuration was satisfactory, the spacecraft was put in the RATE COMMAND control mode and an approach toward the TDA was initiated. The contact was slightly off center, perhaps a couple of inches off center, with very little angular misalignments, and a contact velocity of plus or minus a 1/4 foot per second. There was no Agena reaction noticeable to the contact. The entry of the spacecraft nose into the docking cone was very smooth. The latches apparently set immediately, the rigid sequence began, and we got a Rigid Light just as would be expected in ideal conditions. We sent Stop Rigid immediately upon getting a Rigid Light, cycled the Stop Arm Switch, and got the proper Arm Light amber and, again, extin-

guished. The three static charge whiskers were installed on the TDA and looked in configuration just as they had prior to launch. They apparently provided no interference with the docking operation, and no electrical phenomena of any kind were noted from the spacecraft at contact. We were in position to make the docking at 6 hours and 32 minutes elapsed time, approaching the RKV. When we called the RKV and told them we were in position, we advised them to let us know when they had telemetry solid and we would proceed with the docking. They advised us of that at 6 hours and 34 minutes. On the left side of the spacecraft, which was the side going into darkness, since the TDA was oriented north, in thie spacecraft it appeared to be quite dark at this time. The Docking Light was on and the Index Bar was extended. The impression out the righthand window was that it still appeared to be closer to a daylight situation. Is that correct?

Scott Yes, that's true. It looked almost completely daylight to me on my side.

Armstrong This is perhaps indicative of the difference in lighting conditions as observed through the left

and right-hand windows. I probably would have guessed it to be a nighttime docking. Out the right window it would have been observed as a daytime docking. Incidentally, I turned the Agena recorder on at 06:29:40 and turned it off at 06:35:04, after you had gone on in and rigidized. So, there was about a 5 minute period in there, between the initiation and completion of the docking.

Armstrong We were advised by RKV that the stored program command load, which had previously been sent up by Hawaii, had not been entered correctly and they requested permission to reenter that load. There was a certain amount of reluctance on the part of the crew to accept an SPC load in the docked configuration-particularly since it was obvious that some difficulties were being encountered in inserting the command correctly from the ground. However, we relented, permitting the load to be entered with the understanding that the utmost caution be employed in sending up that information.

Scott We also noted that two times subsequent to that, when either an update to the Agena or a tape dump was required, we were requested to turn the encoder off,

which we did. At the completion of the tape dump we never were reminded again to turn it back on, or informed that the tape dump was complete so that we could turn it back on. I remember a couple of times looking over and finding that the encoder was still off. One other thing that we didn't note before was that on the Status Display Panel, when we got docked and could finally read the time remaining in the propulsion systems, the main propulsion system had 52 seconds remaining, the secondary had 3 minutes and 34 seconds, and the attitude gas was 88 percent remaining.

Armstrong It's recommended that, in the future, the signal to return the encoder to the ON position be enforced, and, should the signal not be given or LOS occur, the encoder be turned on at an arbitrary time, for instance 5 minutes subsequent to the time the encoder was turned off.

Scott And I also believe we had a UHF Enable-Disable in there at one time, too. We had disabled it after we had docked. They requested us to enable it, which we did; then, upon finding the encoder still off, I remember one time disabling the UHF again

with 230. So, we ended up with the UHF disabled and the encoder on.

Schirra What was your configuration over RKV?

Scott Well, when we left the RKV our configuration was encoder on and the UHF had been disabled. The L-Band was off and the radar was off.

Armstrong It should be noted here that at this time we had no real assurance that a valid SPC load had indeed been verified. In addition, a new velocity meter load was requested to be sent up. This was granted. This load, of course, was not scheduled for this station, and we felt that it should have been sent into the Agena at a considerably earlier time. In general, this late combination of loads left a good deal of question in our mind, with respect to the status of the Agena command link to the ground, and we had built up some suspicion of the proper operation of the entire sequence there.

Scott Another point on the SPC maneuver -- we were passed up the information that for that maneuver the Agena would stabilize at 96 degrees for 30 seconds, and our Flight Plan called for stabilization at that point for some 2 minutes before second yaw. I

believe it was sort of confusing as to exactly what the Agena was going to do.

Armstrong We initiated commands just as published in the Flight Plan to yaw the Agena 90 degrees to a spacecraft attitude of 0, 180, 0, or BEF. At the time that we sent Yaw-ON, the yaw rate increased to slightly over 1-1/2 degrees per second, as indicated on the rate needles in the left-hand Flight Director Indicator. Pitch and roll were quite small during the maneuver, although there was an approximate 8 degree spacecraft nose-down pitch difference at the time of the yaw maneuver. It started and stopped crisply, and, in general, it looked much better than our training on the GMS had indicated.

Scott I also noted that it took us 55 seconds to yaw the 90 degrees.

Armstrong This would agree with the slightly greater than 1.5 degrees per second that we observed on the needles.

GEMINI VIII SELF DEBRIEFING

Armstrong Okay. Approximately 7 hours 00 minutes in the flight plan, we were in configuration to perform a Platform Parallelism Check and had just completed the yawing of the Agena-Spacecraft combination to spacecraft BEF position, 0-180-0. We were on the night side. We had docked at approximately 6:34, and that was just a couple of minutes past sunset, so we were approximately 26 minutes into the night side, or thereabouts. In the Flight Plan--at the position where we were sending command 041 with the computer already set up with Addresses 25, 26, and 27 inserted. At the time, the Flight Plan was on the left-hand side and I was reading the commands to Dave, and, at the same time, was working on restowing the cabin into a better configuration after just recently completing the Post-docking Checklist. Then Dave reported that there was some kind of a divergence. How did you remember that, Dave?

Scott Well, we had just finished putting the commands in, and the next thing on the Flight Plan was to start the Agena recorder. I had just sent 041 command to the Agena and written down the time at which the recorder started. I looked up and saw the Spacecraft-Agena

combination starting a roll. With no horizon, it wasn't apparent until I happened to glance at the ball and I didn't really feel it at first. I called Neil and he suggested turning the ACS off. I turned it off as fast as I could and also in a short period of time turned off the Horizon Sensor and the Geo Rate to give spacecraft control to the combination.

Armstrong I would agree that I could not feel the angular acceleration either. We had the lights up in the cockpit and could not really see outside, since it was night and we had no horizon reference. My initial notice of the acceleration was an increase in rates and attitudes on the attitude ball.

Scott Yes. That was my same indication. With no horizon at all, it was hard to tell unless you looked at the ball.

Armstrong Since we expected the SPC-loaded yaw manuever to come sometime within the next 10 minutes and the spacecraft was essentially inactive with the OAMS Attitude Control Power off, it seemed as though the trouble was probably originating with the Agena Control System. So, I turned on the Attitude Control Power, went to RATE COMMAND (we had previously been in PULSE) and attempted

to stabilize the combination. It was my impression that after some period of time, perhaps less than a minute, we essentially had the combination stabilized. But, when we'd let go of the stick, we would again start to accelerate.

Scott And, at some point in there when we had almost stabilized the combination, we sent a command to disable the SPC maneuver, too.

Armstrong That is correct. We were at the ....
I guess I read that command out of the book. 340 I think it was, or something - - S240.

Scott Whatever it was, and I checked it on the card.

Armstrong Right. SPC Disable. Then, noting that the combination was still accelerating and desiring to stop the Agena Control System, we suggested trying to cycle the ACS on in case we could find its Rate Command operative again and help stabilize the combination. We did not see any improvement and later cycled ACS back off. In the meantime, we had sent Power Relay Reset, which I think is 271.

Scott Right. Okay. I think the next thing we both commented on was being able to see the ACS thruster gas, or some gas coming out of there, out of the Agena.

Armstrong This is correct. Since we were approaching a lit horizon, as we would rotate our line of vision through the horizon we could see the cones of ACS thrust coming out of the Agena pitch thrusters. And they appeared to be on full time to me, at the times I could see them.

Scott Yes, I agree. And it was about a 40-degree spread, about 25 feet long.

Armstrong That's right. A wide cone that was illuminated by the sunlit horizon or air glow. Okay, we noted at that time that the gas pressures on the Agena were down to approximately 20 percent.

Scott Right.

Armstrong And we realized then that indeed the ACS was losing gas at a fast rate, either because of a leak or because of all thrusters firing simultaneously. We also had excessive OAMS propellant usage and I called out when we went through 30 percent OAMS propellant on the Propellant Quantity Indicator. At this time, we felt there was some possibility of a spacecraft control system problem at the same time, so we initiated procedures to check out the OAMS system and tried turning the Bias Power off. That did not stop the

accelerations. We turned the Motor Valves off and this did not have any apparent affect either. We turned the Attitude Control Power on and switched Bias Power drivers logic and, we think, switched the roll logic to the pitch thrusters.

None of these actions had any apparent affect, and we were simultaneously, whenever possible, trying to use the thrusters to reduce the rates. We never, however, were able to reduce the rates in any axis completely. It was obvious at this time that the only satisfactory way for diagnosing the control system was undocking the vehicle so that we could disengage possible Agena problems from possible spacecraft problems. To do so, we had to get the rates of the combination down to a value that was suitable for undocking with some assurance that we would not have a recontact problem. We, of course, had to have the OAMS on to reduce these rates and it took us quite a bit of time to get the rates down to a value that we both agreed would be satisfactory to try a release. Upon mutual agreement, Dave undocked with the use of the Undocking Switch and I used the forward-firing thrusters to back away from the Agena as quickly as possible, using about

a 5 second burst. We did not have excessive rates at separation. What would your analysis be there, Dave?

Scott Yes, it looked like a clean separation to me with very low relative rates, and we backed straight off a good 4 or 5 feet before we started tumbling there and lost sight of the Agena. I might add that before we backed off I sent L-Band ON and UHF Enable to the Agena.

Armstrong Shortly after backing off, we noticed that we were essentially losing control of the spacecraft in roll and yaw and we suspected that we were over the lifetime of these attitude thrusters. The spacecraft was continuing, however, to accelerate, and we were obtaining rates in roll at least that approached 200 to 300 degrees per second, or perhaps more.

Scott Yes, I would agree with that. It looked like even more to me, and it was by far more in roll than in yaw. The roll was the most predominate.

Armstrong We realized that physiological limits were being approached, and that we were going to have to do something immediately, in order to salvage the situation. So, we turned off all the OAMS thruster circuit breakers, closed the Attitude Control Power Switch,

closed the Motor Valves, armed the RCS, had no effect using the ACME, and went to DIRECT.

Scott I might add in there that the rates were high enough that both of us had trouble seeing the overhead panel due to the vertigo problems and the centrifugal force as we went around.

Armstrong The RCS DIRECT DIRECT was working satisfactorily and as soon as we determined that we were able to reduce the rates using this mode, we turned the A-Ring OFF and reduced the rates slowly with the B-Ring, putting in a pulse to reduce the rate, then waiting awhile, then putting in another pulse, and so on until the rates were essentially zero in all axes. At this time we carefully reactivated the OAMS, found some popped or inadvertently manually actuated circuit breakers, OAMS control and so forth. Upon reactivating the system we found that the Number 8 thruster was failed on, so we left that circuit breaker off. We had no other yaw thrusters with the exception of Number 8 but the pitch was apparently starting to come back in and we ensured that the roll logic was in pitch. We stayed in PULSE, controlling the spacecraft with pitch and roll pulses then to essentially a BEF attitude.

Scott Do you want to add in there about the hand controller, in not getting anything?

Armstrong Yes. When I earlier referred to the fact that I'd lost control completely it appeared to us as though at that time we had no control out of the hand controller in any axis. I might reiterate that we reactivated the OAMS and found no roll or yaw control with the Number 8 circuit breaker off but pitch was slowly coming back then. It was somewhat ineffective at first, but it was usable after awhile. Sometime later we saw the Agena, approximately a half to a mile below us for a short period of time in daylight. It did not have excessive pitch and yaw rates at this time, nor did it appear to be tumbling end over end. However we were too far away to determine whether there were any roll rates involved in the Agena.

Scott Yes, I agree. It went by pretty fast. We did get to see it wasn't tumbling, but it was hard to tell exactly what attitude or rates it had.

Armstrong Sometime later, when preparing for retrofire, we were asked by the ground whether we had identified the proper operation of the Reentry Rate Control System. So, in checking that system out, we found that we had

regained some yaw control at this time, and guessed at the time that those thrusters may have been cooling down to the point where we were once again getting thrust out of them. So, we used the OAMS then in all three axes to align the platform for retrofire.

Scott You might add that the camera was on there during the undocking at some unknown setting.

Armstrong Roger, we did have the camera on during this time period--the 16 millimeter camera--but we, of course, could not take time to check the settings, and we could not identify at this time whether it was set for daylight or darkness, or for what configuration. That film may or may not come out.

Scott One thing we might add on the stability of the combination--as far as bending we didn't notice any oscillations on the docking or post-docking between the two vehicles after TDA Rigidized. Also during the rolling and yawing maneuvers, when we had the problems with the Agena and spacecraft, I don't believe we noticed any oscillations or bending between the two vehicles. It seemed to be a pretty firm attachment.

Armstrong I am certain that we put fairly sizeable bending loads on the combinations as a result of the inertial loads and also the thruster loads which were long time duration and in all sorts of combinations out of both the OAMS and the Agena ACS. There certainly was no evidence of any relative motion between the Agena and the spacecraft or any noticeable deflections of any sort. After being informed by the ground that they were considering a 6-3 landing area, we realized that we had a reasonably short time to get reconfigured from the stowage point of view to an entry configuration. We immediately started to prepare for that possibility. This involved the restowage of the cameras first. (Both our right and left aft boxes were not yet opened so they did not pose a problem).

We restowed the cameras in the camera brackets immediately and got out the life vests and reattached them to the parachute harness. We started on the unstowage and restowage of the TV Monitor into the footwell which posed some problems.

Scott I guess because we had spent a considerable amount of time trying to get this TV Monitor stowed properly, I believe the method by which it was stowed was a little bit too secure for manual stowage, particularly in the zero G environment. I think in the future if that particular TV Monitor is carried aboard, considerable effort should be expended in trying to stow it or providing a means of stowing it which is compatible with in-flight operations. The strap was extremely tight and it was very difficult to get the overcenter clamp overcentered, and it took about 15 minutes to get that stowed in a configuration acceptable for reentry.

Armstrong We were quizzed upon coming on the next station whether we had completed our Preretro Checklist and what status of our control system mode checks were and so on, and we informed them that we had had little opportunity to work on those areas since we had to get the restowage complete but assured them that we would start and we were told also that the landing area would be 7-3 which

gave us approximately another hour to complete our preretro preparation. The next problem we had, was stowage of the EV visor. The installation of that for Launch was tied in the helmet bag up in the footwell, which of course, is inacessible in the cockpit. You can not, or at least not reasonably, perform the fastenings and reach the required positions to restow in that area. We considered putting it back on the helmet and reentering with the visor on the helmet but that was less than desirabele because of the low tolerances available in the cockpit and the difficulty in maneuvering even with the helmet without the EV visor. It occurred to me at the time from experience with Gemini V in which we had had a similar situation that there was a stowage location that would work. It involved snaking the EV visor around the upper part of the outboard left-hand seat into the back of the seat beside the hatch actuator and this indeed was tried and worked successfully. The remaining items, food packages, bracketry, books, etc., were stowed in footwell pouches and the helmet bags were stowed behind the seats in the area again close to the hatch actuators. A retrofire time had been sent up at the last station and our initial check of the parameter out of the

computer indicated it to be something like minus 50-some-odd minutes but counting up. We checked this several times subsequent and reported it to the ground and it continued to act in a similar fashion. An additional retro load and T_R was sent up from the ground at the next station and apparently operated correctly subsequent to that time.

Scott — I might add that the first T_R load was sent up without our concurrence and didn't give us a chance to insure that the Computer was in Prelaunch (which it was). The notification that a load was coming up and the DCS light appeared almost simultaneously before I could even reach over and grab the Computer Switch to put it in Prelaunch had it not been in Prelaunch. But the second time the procedure of informing us was adhered to and the load got in good. We checked all the MDIU quantities and they confirmed that we did, in fact, have a good load. We might also mention the ATM. Prior to receiving any of the loads, we had loaded module 4A into the ATM and we verified the module with 4A, and then we verified again with module 4B, so we were reasonably certain that the computer was loaded with reentry program without any problem.

Armstrong — We might mention here that during the ATM loads there

was a small amount of pulse firing of the attitude thrusters and this apparently had no effect of memory alterations. At least, we had no indications of malfunctions of any sort during either the load or the verifying.

Scott With the exception of having to turn the Computer OFF and ON to initiate the ATM loading, as happened in the Simulator many times, and the situation at the beginning of the ATM load requires only that the Computer be in Pre-launch and we found it necessary to cycle the Computer ON and OFF or OFF and then ON in Prelaunch before we could get the ATM load in.

Armstrong Yes. Although we had run into this problem on the GMS, it was attributed to be an GMS problem and we had been assured that this situation should not be encountered during flight.

NOTE: Additional orbital operation briefing discussed at the Cape.

Armstrong This is addition amplification over the rendezvous details beginning after the NSR maneuver.

Scott Okay, I think we have discussed removing the residuals after the NSR, and the fact it took us a little extra time, so, we didn't swtich to RENDEZVOUS Mode until 5:40 after the NSR initiation. We picked up the first

data point at 7:20, and from there on down to about 19 or 20 minutes it became evident that we were about 5 minutes behind, as far as a comparison of range/range rate versus time and the nominal trajectory. I might mention that going through this we used a stop watch instead of the panel-mounted clock on the right-hand panel, because of the better accuracy of reading a stop watch and the proximity of the stop watch to the computer. It could be mounted on Velcro between the computer readout and the fuel cell gauges which gives you a good scan pattern to keep up with the systems and also watch the stop watch. I'd recommend a digital timer even being better because many times I'd have to ask Neil what his reading was, to make sure that I was, in fact, on the right minute. You get involved in reading things out of the computer and plotting points and don't watch the specific minutes go by, minute by minute, so you have to make a reference and keep up with it. I guess the range/range rate looked reasonable between NSR and TPI. I verified all the addresses right after the first or second data point. One comment that we made earlier that I'll reiterate is the fact that we got Address 24 the day before the flight. It had been inserted correctly into

the computer. The value in the computer was 13130. The value we had planned on using prior to the day before the flight was 12690, and I think an earlier knowledge of that change would be helpful. We followed the standard procedures right on down to the TPI and the numbers are available on the rendezvous charts. We started our platform alignment at 10 degrees elevation, which is about a degree later than we had planned, but since we were late in time and had plenty of time, we took it at that point and had about 13 minutes of alignment. During that time, the ability to read out Address 84, which is the sine of the radar elevation angle, enabled us to monitor the elevation of the Agena and get the longest platform alignment possible.

Shepard Let me ask you a question on platform alignment. Did you have any idea how close platform orbit rate was, by cross-checking with the horizon when you pitched down to align the platform? Was it off noticeably, or was it not noticeable, or did you make any attempt to..

Armstrong Yes, I made an effort to cross-check, and I could never see a significant pitch attitude error develop between platform alignments, not a visually obvious error develop.

Scott We finished the alignment at an elevation angle of

about 14.9 degrees, which gave us a sufficient number of data points prior to the TPI to ensure a good solution, and went up to an angle of 21.7 degrees, which we selected as Point B, and had a number of things by which to ensure ourselves that had in fact selected the right transfer point. The angular data looked correct. The range agreed with the range that had been passed up in the ground TPI backup, as far as the point at which we could have that range information. The ground predicted 32.5 miles and our data gave us 32.46. We had also been monitoring the total velocity readout of the IVI for the rendezvous, and it had been going down steadily. We got one point at 1 hour and 15 minutes which was 89 feet per second total. The next point went up to 93. We thought perhaps at that time we had missed our minimum transfer point, but the subsequent one went to 72 and then 69 at our nominal Point B. So, we felt reasonably certain that we selected the right transfer point, based on a minimum total Delta V. The START COMP was pushed at the calculated time. In calculating the time at which the initiation maneuver would take place, the onboard calculations gave us a time of 01:26:10, and the ground had given us a time of 01:25:38. So, we were reasonably close

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in time of initiation, too. Comparing the ground, the onboard closed-loop and the backup .....there were some discrepancies in those. The ground had given us a 32 foot per second forward burn. The IVI's in the closed loop solution gave us 25 and the backup gave us 25. So, I think in monitoring the polar plot we felt reasonably certain that the closed loop and backup were, in fact, good solutions. Based on the polar plot, we were riding somewhat higher than nominal and the Delta h between the Agena orbit and our orbit was something like 13 1/2 miles instead of 15, so we knew we would have a lower forward Delta V and were not at all surprised at the answer that came up. There was a discrepancy in the closed loop up-down and the backup solution up-down. I think this may be attributed to the fact that the closed loop had more data points to work with and we had some spongy radar needles as far as our angular information for the TPI. The angular rate in the terminal phase calculations on the backup charts was lower than we expected. Since we were riding higher than our nominal orbit, we might have expected a down correction, but we felt the one we got from the backup solution was excessive. That gave us a 25 foot per second down burn. The closed

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loop said 3 up and the ground had given us a 1.7 up, so adding these up and looking at the forward-aft solution we felt that the closed loop was an acceptable solution at this time and elected to burn it. This we did, on time. After the closed loop we followed through the standard procedures for a nominal TPI to braking and calculated each of the 4 corrections based on the backup onboard charts. The first one gave us a 4.5 foot per second aft burn and a 10 foot per second down, which was consistent with the backup TPI calculation. However, at this time we still had spongy radar neeles in angle and we weren't confident that the angular data read out of the computer was valid for the backup solution. I believe it was just after this first correction calculation that the needle stiffened up a little bit and we started getting some more confidence in the angular data. The second backup calculation was obtained at the same time we got the first closed loop midcourse Delta V display. The closed loop gave us a 12 foot per second forward burn, the backup gave us a 4 foot per second forward. The closed loop gave us a 6 up and the backup gave us a 2.5 up. That seemed like a reasonable comparison, and since we had already elected closed loop we stuck

with it and burned the closed loop on time. The next correction between 13 and 16 minutes, based on the backup charts, we had a 3 foot per second aft and a 2.5 foot per second up, a requirement which we did not burn because we elected to stay with the closed loop. Then, for the 4th correction, which would be the second closed loop midcourse, there was little difference in the numbers. The closed loop gave us a 4 feet per second forward and the backup gave us 1 foot per second aft, but this was almost in the noise. The up-down compared favorably. The closed loop gave us 7 up and the backup gave us 4 up. We elected to continue with the closed loop solution. At the completion of this second midcourse burn, the propellant quantity was 65 percent. As far as the out-of-plane, the TPI ground update was 5.7 left and our closed loop was 8 left. That correlated fairly well. The first midcourse was 1 right which we did burn. The second midcourse was 5 right, which was burned. During this time, the polar plot brought us right into the nominal trajectory, and at the completion of the second midcourse we had come down from our height dispersion onto the nominal trajectory and were following a nominal path on in to the target. So, we had a

reasonable amount of confidence that the closed loop had in fact done the job it was supposed to. From that point in, we zeroed Addresses 25, 26, and 27 and pushed START COMP to pick up the burns on in to the final braking. The propellant quantity at the completion of NSR was 75 percent and at the completion of the TPI, 65 percent. So we used 10 percent in the TPI and two midcourse corrections. The first braking was performed at 28 minutes after TPI and it was 8 feet per second aft. The other numbers were stated earlier, as far as specific times, range, range rate, and the amount of braking that was performed. Finally, at 42 minutes after TPI we were station-keeping at about 150 feet and the propellant quantity was 55 percent. As wer approached the Agena, I continuously punched range and range rate and gave it to Neil, range and range rate because his analog isn't as good as the digital. The last angle I wrote down was at 30 minutes. We were 1.05 miles out and I had 123 degrees, I quit reading out the angles after that.

Armstrong From that point we drifted back, back underneath, and actually approached from the rear subsequent to that time period. During the phase when we were in darkness, approaching the Agena from underneath and

tracking the acquisition lights, the running lights were never visible. It wasn't until we got quite close to the Agena in daylight, perhaps less than 200 feet, that the running lights were identified as being operative. The green running light at the engine end of the Agena was extinguished. The cone light was operating as expected and was useful, felt to be useful, during the docking operation. Although we were in the period between daylight and darkness at the time of docking.... the spacecraft was pointed toward the south, with the TDA north and the left window was on the dark side of the spacecraft...the appearance when looking through the left window was one of a nightside docking. The cone light combined with the docking light on the spacecraft provided ample illumination of the Agena/TDA combination, to provide easy attitude reference just by visual means, without augmentation by means of running lights, platform reference, or any additional instrument requirements. The first contact was made at an estimated one or two inches to the left and slightly below the axis of the centerline of the Agena, such that the initial contact of the spacecraft and the whiskers on the TDA were observed through the left-hand window on the

dark side. There was no visual evidence of any discharge, corona, or arcing at the time of contact.

Scott — The right side was in daylight and it was essentially a daylight docking. I also observed no contact sparks or any abnormality upon initial contact.

Shepard — Let me back up and ask a question. Do you have somewhere, either on your rendezvous plot or on tape, at what range you were during the braking and the approaching maneuver when the Agena came into sunlight again?

Armstrong — Yes. At least for the braking phase we specifically mentioned at what ranges we applied what Delta V's.

Shepard — I'm talking about when the Agena first came into sunlight, so we can correlate the range beyond which you could not see the running lights during the dark.

Scott — Based on initial calculations, using the Rendezvous Chart, we were approximately 3.8 miles from the Agena at sunrise.

Armstrong — I might mention that while we were station-keeping along the side of the Agena, actually, I think we were in a BEF position, we extended the Index Bar and took movies with the camera at the time. The Index Bar extension was initially fast for the first half travel, and then relatively slow, I thought, for the last half of the extension. It slowed down near the

end. Hopefully, the films will illustrate this. I would like to add one comment on the stowage. We attempted to restow the camera in the camera box in the centerline stowage area and found that the pins and holes would not align. This, of course, had been a problem on previous spacecraft, but the correction to the problem was apparently an over correction, because the door pins now extended below the holes in the bottom of the centerline stowage area. This was finally alleviated by attaching some straps to the bottom of the camera box and pulling the entire combination down from the bottom by one person while the other individual attempted to slam the door shut and engage the catches. We had a good bit of difficulty in getting the catches to engage completely, and there was some concern that the door would not indeed stay down. But, after a half dozen attempts, we finally were able to lock the spring engage system to the point that we felt it was secure.

FCSD Rep How long a period of time did this take?

Armstrong We must have worked probably 15 minutes on closing the camera box door.

Scott We divided our time about equally between the camera box stowage and the TV Monitor stowage. That took most of the time.

5.0 RETROFIRE

Armstrong Upon informing the ground that our T_R was counting up rather than down they informed us that the T_R Indicated on the ground showed that it was counting down and we were in sync. The RCS was checked in both rings in all modes and was operating satisfactorily. REENTRY RATE COMMAND was checked as well in as much as this was the preferred mode for the reentry sequence subsequent to 400 K. We completed the preretro checklist as planned and the A-Ring at this time had 2400 psi in it and the B-Ring 1600 psi. The pressure in the B-Ring had come up somewhat after the temperature had increased (as compared with the earlier readings of 1500). We checked the T_R by reading 02 out of the computer several times and it seemed to be operating satisfactorily counting toward our GTTRC and that was after the second load came up from the ground.

5.1 TR-4:16 Checklist

Armstrong The next surprise was not receiving an amber light in the Indicate Retro Attitude sequence light at T_R equal 256. Normally three lights come on with this sequence: The RCS Arm, the Battery Light, and the Indicate Retro Attitude. Since the batteries were put on earlier than this in our normal sequence and the RCS had been armed

earlier in the flight they were already both green and the only light remaining to be illuminated was the Indicate Retro Attitude light. It did not come on; we pushed that telelight switch and it illuminated green and we promptly checked T_R again with our clock to be sure that it was counting down. It was counting down in sync at that time. We had confirmed prior to the 256 checklist (in the preretro checklist as a matter of fact) upon ground request that the 256 circuit breaker was closed, and it was.

5.2 T_R-1:00 and T_R-30 Checklists

Scott T_R-1 was nominal. We pushed the SEP OAMS, SEP ELECT, and SEP ADAPT and all three of them went as planned. We armed the Retro Squibs at T_R-30 and we picked up the count from the ground. I guess it was remoted through Kano and heard them from 6 down to 2, as I remember.

5.3 TR-0

Armstrong I am not sure that I heard the word "retrofire" come through.

Scott I don't think I did either, but we did hear some of the count and they were counting with us. At about T_R-1, I pushed the Arm Auto Retro, we got an auto

retrofire and the Comp light came on immediately and I pushed a manual retrofire about a second after the auto. All four retro rockets fired; I'd say it was probably about a half second between the first and second and the second and third and a little longer (maybe a second to a second and a half) between the third and fourth. The IVI's at the completion of the retrofire, were 292 aft, 0 left and right, 114 down. The nominal values passed up from the ground had been 292 aft, and 110 down, so we were only 4 off down which changed our back-up angle from 50° to 52° based on the onboard charts. The addresses read out of the computer: out of address 80 we got minus 292.5, 81 was 00003, and 82 was 0114.1 which confirmed the IVI's.

5.4 Retropack Jettison

Armstrong The Retro-Jet Light did come on correctly at T_R+45 seconds and we jettisoned retros and the Index Bar. There was no change in the IVI's with that signal. We reported retro-jet about two seconds after Index Bar jettison and still spotted a few more sparks out of the hole that the Index Bar had extended from. Retrofire was in darkness. The computer addresses were read after the Retro Section was jettisoned.

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6.0 REENTRY

6.1 Attitude Control Modes

Armstrong After retrofire, the spacecraft was rolled inverted and pitched to pick up the horizon. As it turned out, there was no visible horizon in this lighting condition and we actually waited until we broke into daylight or at least partially into daylight sometime later before we actually set up the spacecraft attitude in pitch to pick up the proper pitch attitude. It was our intention to save as much fuel as possible since prior to retrofire we were informed that we had four pounds of fuel in Ring B and eleven pounds in Ring A. We flew RATE COMMAND through retrofire (both rings) and switched to B-Ring PULSE for the reentry until such time as we felt that we needed to go to REENTRY RATE COMMAND and then switch rings when we ran out of fuel. The time trajectory from retrofire to 400,000 feet was performed over the African and Asian Continents and our reentry was over land primarily, most of the time. We came down over the Himalayas and it was very obvious to both of us that we were descending at a rapid rate. We actually both had the feeling of coming closer to ground visually. As we approached 400,000 feet we picked up the 52 degree back-up bank angle that we had

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computed onboard and the 400,000 foot indication out of the computer came precisely on time. This gave us a good deal of confidence that the computer was indeed working to some extent. Dave reported guidance at approximately 290,000 feet.

6.2 Guidance

Scott — And, that also was on time, which was 3 minutes 15 seconds after 400 K. This was also another confidence factor.

Armstrong — The R_N minus R_T value that had been predicted by the ground was 77 miles. The accuracy on this as agreed in preflight discussions was 50 miles. The value observed on the downrange needle at the time that crossrange and downrange errors became available was approximately 45 miles. It was considerably more steady, should we say less oscillatory, than had been observed in simulations in the Gemini Mission Simulator. It actually was sufficiently steady that no oscillation magnitude could be determined, and we stayed on the 52 degree bank angle, bank left, for approximately a minute before committing to the closed loop.

Scott — As a matter of fact, I don't think during that minute the needles moved more than 5 miles from that initial deflection.

Armstrong That's right, and the crossrange was indicating some 2 or 3 miles to the right of the target, so we rolled from 50 left to approximately 30 degrees right to pick up the initial roll bug deflection and start taking out the crossrange error. The subsequent control motions were maintaining lift vector up, slightly banked right for perhaps several minutes before nulling the downrange and crossrange errors. At this time, a 15 degree roll was commanded and the g's were building up to approximately 4. The RCS B-Ring pressure was down below 1400 pounds at this point and I did not want to run out of control right at the peak g, so I switched to A-Ring and turned B-Ring off, saving what little if any fuel that was remaining in that ring for the Drogue. The roll commands of 15 degrees per second could not be matched with the REENTRY RATE COMMAND. Approximately 8 to 12 degrees per second was all that was available for full roll stick deflection. The roll command logic, which is difficult to interpret and requires changing the direction of the roll from right rotation to left rotation at inconvenient times during the g-pulse, was felt to compromise ability to accurately control the spacecraft during this phase and was also felt to require an excessive amount of

fuel, particularly in view of the fact that we were fuel-critical. The maximum g was approximately 6. After peak g the roll command indicated approximately a lift-vector-up orientation which we acquired, shortly after which the altimeter began to move off its maximum value of 95,000 feet.

Scott I believe that 100,000 feet came at just about the right time.

Armstrong I don't recall now cross-checking the clock at 100,000 feet.

Scott I remember calling it and you said, "Yes, it is starting to come off the peg", or something like that.

Armstrong I had checked several other times, blackout and so on. We had reset the clocks to "plus time" and were operating on an elapsed timer with plus time from retrofire.

Scott You might mention that on the way down we saw the retro section trailing.

Armstrong We saw the retro section quite a good distance behind us, up and to my left, and observed it burning with orange color and periodic flashes of green.

Scott Also there was quite a bit of sparks and fire coming off the top of the spacecraft near the R and R Section.

Armstrong During the early part of the reentry, the outer coating on the window started to peel off from the center of

the paint outward, much like a green cellophane coating that would be peeled off in strips from the center of a book cover.

Schirra Did it look a little jagged?

Armstrong Yes.

6.3 Drogue Chute Deployment

Armstrong The Landing Bus Arm was actuated after passing 70,000 feet and the Drogue extended at approximately 50,000 feet, immediately after which we turned the B-Ring back on and went to RATE COMMAND. The oscillations of the spacecraft-drogue combination were of the order of plus or minus 20 degrees, as measured on the ball. I was particularly looking at the ball and it looked to be like an approximate 40-degree angular deflection on the ball. Looking out the window it looked somewhat more severe than that.

Scott I thought it was more of a . . .

Armstrong It was fairly severe. The fuel in both rings was depleted between that time and prior to main chute deployment.

6.4 Main Chute Deployment

The main chute was deployed at 10,000 feet and operated as expected.

6.5 Impact Targeting Confidence

Scott The lattitude and longitude out of the computer after 80K, at the end of guidance, was 25.05 North and 136.09 East, which was reasonably close. I don't have the numbers passed up right now, but I believe it was something like 25.01 and 136.01. That was the target point, so we knew we were reasonably close to the impact point.

Armstrong Yes, the needles indicated no significant deviation from the target point.

Scott Yes, we did report both of these to the ground, but I don't know if they heard us or not. We never had any contact from the ground after we started blackout.

Armstrong After main chute extension we used the cockpit mirrors to look back down through the windows and determine that we were indeed over water. We thought this was worth checking since our entire reentry sequence had been over land. Determining that there was indeed water below us, we went to Landing Attitude. The jolt associated with landing attitude was fairly severe, I would say. Moderately severe.

Scott I think being prepared for it minimized the impact.

Armstrong Nothing came loose in the cockpit, and we certainly didn't have any injuries of any sort as a result of that.

Armstrong At 27K we turned on O_2 HIGH RATE and opened the Cabin Air Recirc one-half. We remained in that configuration until we got down to 2,000 feet. At one point, I had to pop my ears and open my visor briefly. There was considerable amount of fumes in the cockpit, but the suit loop was reasonably clean. You didn't smell anything, did you, Dave?

Scott No, I also checked the inside of the cabin and the odors were extremely strong, the fumes were very strong inside the cabin. I closed the visor again and the suit loop was satisfactory, although it was quite warm in the suit since the fans were off in this configuration.

Armstrong At 2,000 feet we closed the Water Seal and opened the Repress. When we got on the water we opened the Vent and the Snorkel. It seemed to work reasonably well, I thought. Our touchdown, I thought, was quite hard.

Scott I agree.

Armstrong Quite a bit harder than I had expected, and apparently this is a matter of how you happen to hit the waves in combination with the part of the oscillation that you're in on the chute at the time you hit. The spacecraft rolled around somewhat on touchdown. Both

windows were under water at one time or another, although not necessarily at the same time. Since the seas were somewhat rough and the swells were big we chose to jettison the chute immediately upon touchdown and the chute stayed close to the spacecraft, floating on top of the water, and it was retied to the spacecraft by the swimmers when they arrived at the scene.

Scott We might add that one recovery aircraft had us in sight at 5,000 feet.

7.0 LANDING AND RECOVERY

7.1 Impact

Armstrong — We felt a considerably harder impact than we had expected from comments of previous flight crews.

7.2 Postlanding Checklist

Scott — I'd like to recommend that the Post-landing Checklist be written in a format describing what is to be done, not what is not to be done. It takes a considerable amount of time to figure with switches you don't throw, instead of listing those that you do throw. Also, we should probably have a procedure page somewhere in the Flight Plan Book on recovery operations, particularly in remote areas.

7.3 Communication

Armstrong — Immediately after splash, we started communication procedures to the rescue forces. First on UHF, broadcasting in the blind our call sign and latitude and longitude as obtained from the spacecraft computer. We enabled the HF receiver and extended the HF recovery antenna, and we had

reasonably good reception of oriental music. We keyed the HF/DF transmitter continuously for sometime after splash and periodically switched to HF and transmitted our call sign and position in the blind. Approximately 15 or 20 minutes after splash we heard airplane engines overhead and attempted to contact that aircraft both on HF and UHF without results. We were using a call sign NAHA RESCUE 1, which we believed to be the aircraft that was expected to be in the recovery area at the time of landing.

Scott And also NAHA SEARCH 1 was used.

Armstrong We also used the call sign NAHA SEARCH 1. No reception on HF or UHF was obtained until the aircraft returned and the para-rescue people jumped toward the spacecraft. We observed the first para-rescue person in his descent from the aircraft. We had satisfactory recovery status information onboard the spacecraft from the ground prior to retrofire. We had sea state, altimeter setting, the rescue forces situation, the call signs of rescue aircraft, and information that the destroyer Mason was expected to arrive at

06:54 which would be something over 4 hours after splash, as I remember. We were given seas as being 3 to 5 feet and we had taken one Marizine tablet prior to retrofire.

7.4 Postlanding Spacecraft Status

Shepard What about smell?

Armstrong The RCS fumes were quite strong in the cockpit during the descent and after splash the odors were still very strong, but they were felt to be primarily the odors of the heat shield. Those odors remained for our entire stay duration on the water. The main chute was jettisoned shortly after splash because of the spacecraft motions on impact where both windows were under water at one time or the other. It was felt safest to jettison the chute at that point, however, the chute stayed in the water floating in the vicinity of the spacecraft, and was later tied to the nose of the spacecraft by the swimmers. The windows: The left-hand window was completely fogged over and it was extremely difficult to see through at any time and the right window was somewhat fogged over but it had some clear spaces around

the edges as I recall.

Scott — That's correct.

Armstrong — Dave observed some water leakage into the spacecraft. Did you visually observe that or just hear it?

Scott — It was coming from the aft hinge side of the right hatch. But just drops.

Shepard — How about the Electrical Power Checks?

Armstrong — Yes, well we powered down when we got in the water and I think we commented on the Electrical Checks.

Scott — Yes, I didn't make any checks per se. But it took us quite a long time to get the HF antenna in when the ship appeared and we were cleaning the spacecraft up. I'd estimate about 5 minutes to get the antenna retracted....

Shepard — Had it been bent, or do you think it was just slow action?

Scott — Just slow action. You could see it, it was straight.

Armstrong — Yes.

Scott — It probably just took it a long time to get in.

Armstrong — I don't recall the Secondary Oxygen Pressure but

the Repress was left on for some period after splash.

Scott — I don't remember the pressure either.

Armstrong — I have no particular comment on the hatches. We were notified from the.....

Shepard — Did you need a splash curtain?

Armstrong — No, we did not. We left the hatches closed since the swimmers were apparently having a good bit of difficulty getting the flotation collar installed. We felt the safest thing to do was leave the hatches closed and locked. After some period of time we opened the left hatch and cracked it so that we could talk to the swimmers, and after having been assured that everything was OK on the outside, we locked that hatch again. We received information from the swimmers, who had radio contact with the aircraft, that Houston desired us to activate the Left-Hand S-3 Unit 1 and give them a time. We gave the time of 12:55, and thinking that this would be enough time for them to get back in contact with Houston, so they could run the experiment on the ground at the same time. As it turned out, we didn't activate

the experiment until 13:02, about 7 minutes after the stated time.

7.5 Comfort

Armstrong — The suits were of course quite warm. The cabin was very warm. The ventilation was provided by maintaining both suit fans on after splash. I finally disconnected my hoses and put an interconnect on, since the vent flow was pretty warm. Dave felt like he preferred to have the vent and kept it operating on his side.

Scott — In my suit the vent was cooler.

Armstrong — It has to be noted here of course, there was a difference in the suits. Mine was conventional G4C and Dave had the heavy bunny layer on.

Shepard — When did you take your helmets and gloves off?

Armstrong — We took the helmets and gloves off as soon as possible after hitting the water.

Shepard — And you left off the neck dam and the cuffs?

Armstrong — Yes. For ventilation reasons. The sea condition had been predicted to be 3 to 5 foot waves, and the actual sea condition was 3 to 5 foot waves superimposed on 10 to 15 foot swells, a relatively rough sea condition, and there was no question

that it was prohibitive for the SA-16 to land in the water out there.

7.6 Recovery Team

Armstrong — The recovery team apparently had quite a bit of difficulty in installing the flotation collar. It was our estimate that it took something between 30 to 60 minutes for them to install the collar after their arrival, which was 20 to 30 minutes after splash.

FCSD REP — Was this because of the sea condition?

Armstrong — I am not completely sure what their reasons were.

Scott — I think that was probably most of it because they were sick too.

Armstrong — There were three swimmers and they were all violently ill. I'm sure this was slowing down their operation on the outside to some extent.

7.7 Crew Egress

Armstrong — The egress was performed at the destroyer. We waited until the destroyer pulled up alongside the spacecraft, and the spacecraft was attached to the destroyer by means of lines. We egressed directly from the open hatch of the spacecraft to the Jacob's Ladder. This was somewhat

difficult because of the high sea state and the spacecraft was bobbing up and down alongside the destroyer, perhaps 10 to 15 feet, I would say, bumping along the side. The nose ring on the spacecraft was dented rather badly as a result of the contacts with the side of the destroyer. They could easily saved the chute, but due to a misunderstanding between the swimmers and the hoist operator they lost the main chute during the process of spacecraft recovery.

Scott — It got tangled up in the screws.

Armstrong — Yes. I think it did.

FCSD REP — Did you both egress through your respective hatches?

Scott — No. I closed and locked mine and got out on his side.

8.0 SYSTEMS OPERATION

8.1 Platform

Armstrong During alignment, between day and night, during the twilight period, we had some spurious firing and some scanner ignore lights. The new ball markings on the attitude indicator were a great help in a number of phases of the flight, as were the markings on the needles. The accelerometer bias was significant, initially in the flight.

Scott The Accelerometer Bias Check that we performed over Carnarvon at 50 minutes resulted in the readouts of: Address 80, minus 0004, Address 81,00001, and Address 82, minus 0004. We noted that the ground sent their computer summaries and apparently considered the Bias Check complete after about a minute and a half. We continued on with the full three minutes to get these readings. Subsequent to that, on each of our burns we had difficulty in nulling the residuals. It looked like there was something wrong with the accelerometer bias in the computer - - the ground sent an update and said it was fine - - or the computer was processing the accelerometer data slowly. Several times we put a correction in to null a residual and called it up on the computer. Five seconds later we called it up again and got a different value. So, there was some problem there and it resulted in a delay in time, taking out the residuals, and we were not certain that each time we had completely removed them.

8.2 RCS

Armstrong The entire flight was flown with the RCS heaters OFF

and no RCS Heater Light was observed at any time. The Reentry Rate Command System was apparently unable to produce a rate of 15 degrees per second with full roll stick deflection. The actual spacecraft roll rate at max stick deflection appeared to be varying from 9 to 11 or 12 degrees per second. RCS fuel was exhausted in the vicinity of 30,000 feet after the drogue chute had been extended and prior to the main chute being released.

8.3 ECS

Armstrong The temperature configuration of the suit circuit/cabin circuit combination was marginally satisfactory. The suit heat exchangers were maintained at full cold and the suit fans in two-fan operation. With this configuration and a minimum of physical exertion the temperature levels were satisfactory.

Armstrong It was noted early in the flight that the ECS O_2 pressure had built to the top of the vent range. It was approximately 830 psia indicated. We were advised by the ground to turn the auto-heater OFF, which we did, but the pressure, as best I remember, remained at the vent value. Coolant loops were operated on A-Pumps throughout the flight. Upon the first use of the water gun, we found that the water was filled with gas, as recorded on some very early spacecraft, and the water came out almost like a foam. As the flight progressed the amount of gas in the water seemed to decrease slightly, but at last use of the water gun, there was still excessive gas in the water.

8.4 Communications

Armstrong After touchdown, UHF contact with the airplanes was

attempted when the aircraft were apparently within relatively close range. This was not successful until during the time period when the Para-Rescue Jumpers were approaching the spacecraft. We had one short transmission which was loud and clear back and forth between the spacecraft and Naha Rescue 1. No other transmissions were satisfactory. HF performance was not attempted during orbit, but was attempted after splash. The landing antenna was extended and HF transmissions attempted. The only reception on HF was oriental music.

Scott — We got two DCS reentry updates. On the first one, T_R was passed up before we had a chance to ensure the computer was in PRELAUNCH and the coordination with the ground wasn't too good on that, I thought. The load did not get in, apparently, because on reading out the T_R we were counting up. Later on we got another one, I believe, from the RKV, which did get in properly and was confirmed by the MDIU readouts.

8.5 Electrical

Scott — Fuel cell operation was good. Throughtout they provided all we needed, but there was an interesting split between the top sections. On insertion, we had main buss amps on Section 1 reading 13.5 and on Section 2, 8.0 equally distributive in each section amont the stacks. On a Preretro Checklist, on Section 1 the main bus amps were 15.2 and on Section 2 they were 7.5, again equally distributive among the stacks. But it showed that Section 1 was pulling more of the load all the time, and almost twice as much as Section 2 by the time we got to reentry. We made two purges, according

to the flight plan, one of which was coordinated with ground at the proper time and the other one based on a nominal time during flight plan. The second one was at an elapsed time of 8:25. The H_2 Delta P was reported for each of the sections on each purge, and it is available in the flight plan data. The purges were nominal. The Delta P light came ON on Section 2 on the first purge only, and came on for both sections on the second purge each time in the H_2 part of the purge.

8.6 Onboard Computer

Scott At Guidance Initiate during the launch we got a deflection of the pitch and yaw needles. The yaw needle was as expected. It went approximately 4 degrees, indicating a yaw right error, and came back in as predicted. The pitch needle did not deflect as much as we had expected. We had expected something like a 12 degree pitch and it only went, as I can remember, some 2 or 3 degrees and came in immediately. The rest of the time, after the initial nulling of the needles, pitch stayed at zero and yaw was about a quarter of a degree.

Armstrong At SECO, Address 72, Inertial Velocity, read 25726 and the fore-aft IVI read 4 aft. The burn for this condition was 5 feet per second forward, and 7 seconds of thrust were applied. The IVI's transferred from 4 aft to 10 aft, but 72 now read 25748, a difference of 22 feet per second as opposed to the 6 shown on the IVI's.

Scott . . . . minus 0015 and after the burn was a minus 0002.

Armstrong A number of maneuvers were performed after the accelerometer bias change had been completed. Upon performing

these maneuvers an attempt was made to reduce the residuals to zero by reading Addresses 80, 81, 82, and applying their appropriate Delta V's. It was not obvious that the residual loops were acting correctly, inasmuch as some variation in these addresses was observed repeatedly. It was characterized by a change in value with no input acceleration. For example, one reading might be 0002, the next reading 0004, and the next reading 0002 with no thrust inputs in between. Address 82 appeared to be the most inconsistent of the three and, upon a number of experiences with this situation, we gave up attempting to reduce residuals to zero at the end of each burn - - that is, precisely to zero.

Armstrong The Rendezvous Computations are discussed in the Rendezvous Section of the debriefing - - the most important anomaly that was observed was a variation in the reduction of total velocity with decreasing range. On at least three different occasions the total velocity would decrease and increase and then decrease again. Perhaps we can recall some of those numbers.

Scott Yes, at one point at 39 minutes after the NSR we went from 421 to 373 to 389 to 374. Again, at 54 minutes we went from 289 to 272 to 289 to 263. Finally, just before the TPI we went from 102 to 89 to 93 to 72 and then 69. In addition, the range rate readouts were not as consistent as we had seen in simulations. Normally, in simulations we would read a consistent number of range rates, like maybe 6 or 7 quantities of 156 feet per second in a row, whereas, during the actual rendezvous they were scattered from values such

as 154, 195, 153, 154, 151, in consecutive order.

Scott — We attempted to load Module 4-A in the ATM for reentry and check the initial conditions, all of which were according to the ATM procedures. The computer was on and in PRELAUNCH. Upon entering the proper address and then switching the ATM ON and to Automatic, we got no running light and no response in the IVI's. We cycled the ATM to the OFF position, and then turned the computer OFF and then ON in PRELAUNCH, waiting for the diagnostic to be completed. We then reinitialized the ATM and it worked properly. We had seen this happen a number of times on the simulator, but it was explained to us at that time that it was a simulator problem. Subsequent to that the ATM worked properly. Module 4-A was loaded and verified, and that was again verified by 4-B, all according to what we had expected. During this time there were a number of thruster firings.

8.7 Radar

Armstrong — Radar acquisition of the Agena was obtained with a solid lock at approximately 179 nautical miles. Visual acquisition was at approximately 76 miles, and at that time the radar boresight was approximately 1/2 degree below and 1/2 degree to the left of the optical boresight, as determined by the reticle pattern of the optical sight.

FCSD Rep — What was the magnitude of the Agena you had at this time when you picked it up?

Armstrong — It was quite dim, just maybe fifth magnitude. It was in daylight, so it's a little bit difficult to determine. During the period of time when the radar range

was between 45 and 25 miles the angular information appeared to be considerably degraded over the other parts of the trajectory, and the boresights varied up to plus or minus 2 degrees. This was apparently a servo lag problem and disappeared at ranges inside 25 miles.

8.8 Crew Station

Armstrong Sequential Telelights. At T_R-256, three lights normally come on amber: the Battery, RCS, and Indicate Retroattitude. The batteries had been put on prior to this time and the RCS had also been armed earlier so the only remaining light was Indicate Retroattitude. It failed to illuminate amber at T_R-256. The circuit breaker was checked and was closed. T_R was called from the computer and appeared to be in sync. No other explanation for this light not illuminating has been offered. No attempt was made to test it amber between that time and retrofire. Earlier, however, the test was completed satisfactorily. Switches and Circuit Breaker Panels - - - some unexplained circuit breaker openings were observed. The Fuel Cell Hydrogen Heater Circuit Breaker opened, the ATM Circuit Breaker opened, the Antenna Select Circuit Breaker opened - - -. All the onboard data was satisfactory, but as usual was not ready for use until a relatively short time before the flight. It should be recognized as a great training benefit to have actual, or very near actual, onboard data for use in the simulator for a period of time of at least several weeks before the flight.

Scott Well, on the Flight Plan the Rendezvous Charts - - I think, if I were doing them again, I'd take the Ren-

dezvous Charts and include them in the Flight Plan in sequence and include on them such unassociated tasks as fuel cell purges, AOS's, LOS's, and camera settings. I think from going from the Flight Plan to the Rendezvous Book and back again we wasted some pages in the Flight Plan and we probably left a few things out.

Armstrong In addition to the normal checklist cards, a number of other cards were constructed to be used somewhat like checklists for special purposes. These were specially designed cards to be attached by means of velcro to specific places on the panel that were not being used during that part of flight plan. On the left hand instrument panel, cards were placed over the GLV tank indicators and engine lights, over the altimeter and rate of descent indicator, and over the radar range-range rate indicator at various times during the flight. This made a handy reference place, was within the scan pattern, and was found to be a useful technique and is recommended for trial for other flight crews.

Scott This could also be applied to the right side in the panel space available in between the guages.

Armstrong Maps and Overlays - - we were surprised to find out that our 7-3 recovery area was not listed on our onboard orbital map. Fortunately, the weather map that we had been given just before flight did have the recovery areas on it. However, in the future, I think data of this sort should be included on the orbital maps, since it doesn't really detract from the maps accuracy and could be included at no cost. In regards to stowage, the TV monitor was one of the most difficult items to manage in the cockpit; both the launch

stowage and the orbital stowage and restowage were difficult to operate, and required excessive time. The requirement to stow the EVA visor for retrofire posed a problem and we finally found a place around the back of the left-hand seat that was suitable. The left-hand seat belt for some unknown reason was tightened all the way against the stop priot to retrofire and still wasn't tight. Its not known why this appeared to be bigger prior to retro than it was for launch. Installation of the life vests on the parachute harness for reentry took more time than was desired. It would seem advisable to attempt a redesign of the life-belt-life-vest attach mechanism to provide quicker reconfiguration for an emergency reentry. In addition it would help to mark the vests as left-right, up-and-down, so that when it was retrieved from temporary stowage you can immediately determine at what place on the harness it was to be attached.

Note: This section was taped at a later session and added to System Operations.

8.9 OAMS

Armstrong Some comments had been made by ground stations concerning regulated pressure indicated as zero subsequent to 7 hours. Now this was not noted during flight. The read pressure appeared to stay at about 300 at all times that it was noted. The OAMS reserve tank or BW tank was not actuated during flight. Some question has been raised about the time at which the number 8 thruster was observed to be failed in the ON condition. It is to be noted here that at the time of

the initial divergence the thruster was not heard to fire nor was it seen. In the night condition of the time that thruster would normally be observed as reflected glow in the left-hand window.

9.0 VISUAL SIGHTINGS

9.1 Countdown

Armstrong During the count, we unstowed the cockpit mirrors and verified that the ground fairly near, below the spacecraft could be observed from the cockpit in the vertical attitude. This was to be used later, after main chute deployment, to ascertain that the spacecraft was definitely over water prior to going to the landing attitude.

9.2 Powered Flight

Scott Just after lift-off, we went through a thin deck of clouds and that was the first time that we had a sensation of really having a vertical velocity. Just a very short penetration.

Armstrong During staging, we had the definite impression of flying through some sort of fireball. It was evidenced by a bright orange glow forward of the cockpit, just at the time of the separation and engine two ignition sequence.

FCSD Rep Did you notice any window smears?

Armstrong Yes, we both felt that there was a deposit on the window at the time, as a result of that fireball.

Scott I think it was a little more pronounced at the top of

the window, or at least it was on mine. Did you notice that?

Armstrong I didn't notice particularly where in the window the thickest deposit was. The horizon came into view as expected from the GMS visual simulation. SECO was accompanied by a large number of particles, bits of debris and small globules of fluid radiating away from the spacecraft in all directions, predominantly forward along the flight path, since this was the direction that we could see best. At fairing jet, we had an eye position that was fairly high in the cockpit, floating up against the top of the cockpit, and could see the scanner covers go along with the nose fairing. This operation was accompanied by yaw right and pitch up moments. We did not have any observation of the second stage booster, subsequent to separation.

9.3 Orbital Flight

Armstrong During the initial visual acquisition of the Agena target, 4 or perhaps 5 objects were observed in the near vicinity, simultaneously. As we approached closer to the Agena, all but one of these objects disappeared. One object was sufficiently bright to be confused with the Agena, however, it drifted up-

ward in the optical site, at what may have been orbital rate, and was thought, perhaps, to be a celestial object, such as a planet. After rendezvous with the Agena, careful visual inspection of the Agena exterior condition was performed. No abnormalities were noted on the Agena, the dipole was extended, whiskers were extended, the target docking adapter was in the unrigid condition. The engine package looked as expected and the silver spheres were brilliant, highly polished. The S-10 package was installed properly and appeared to be in good condition. All exterior paint on the Agena, also appeared to be in good condition. As the Agena-Gemini combination moved from darkness into daylight, particularly in that region of time where there was a airglow layer, or sunlit horizon, with all other parts of the sky being relatively dark, the Agena ACS operation could be visually observed. The thruster plumes appeared to extend from the thruster nozzle outward for a large distance, perhaps as much as 25 feet, and the cone was relatively wide angle judged to be somewhere between 40 and 80 degrees. The consistency of the exhaust plume itself might be identified as a slightly milky color, as

compared with the surrounding black void, like a fog, like a thin spray.

FCSD Rep It was homogenous, then?

Armstrong Yes, it appeared to be completely homogenous.

FCSD Rep Anything else?

Scott No, I didn't see anything else.

Armstrong These thruster plumes could not be seen against the black sky, black ground, or daylight sky.

Scott They had this in the in-between.

Armstrong Right.

Scott During the entry of the second night side pass, I looked up at one time to find the fire that Neil said he saw on the horizon and in about a 2 minute period, I observed 2 meteors; one of which traveled from about the center of the windscreen, from right to left, down at about 30 degrees; and the other was about from the center of the windscreen, down to the right at about 60 or 70 degrees, with about, I guess, a 15 to 20 degree tail.

FCSD Rep What was the spacecraft attitude?

Armstrong SEF. It should be noted that the horizon was difficult to see on the night side if the cockpit lights weren't reduced to an absolute minimum. At that time, the

horizon could be identified quite readily and the horizon that was visible was probably the top of the airglow layer, since it was quite evident that stars were visible for considerable distance, 5 or more degrees below this very definable horizon. This was felt to be the only usable horizon for sextant sightings for this condition.

Scott I think you could probably make a sighting within about a degree on that horizon. It was felt that all attitude thruster firings could be observed at night by reflection of red light from the thruster plumes on the windows, either the right or the left-hand window. The forward firing translation thrusters were intermittently observable only. They were not observed as a cone of light extending forward from the spacecraft, but rather as periodic flashes during the time they were being operated. A number of thunderstorm areas were observed from the spacecraft in both day, night and dawn conditions. The critical development of the thunderheads was readily evident both when the spacecraft was passing over the storms and also when the storms were located out at the horizon. In the case of the horizon, of course, the development

could clearly be seen as a profile against the airglow and sunlit earth horizon. Lightning was observed in these vertical build-ups at night and particularly noted in the area Northeast of Australia.

9.4 Retrofire and Reentry

Armstrong The retro pack and retro adapter section was observed to be reentering several miles behind the spacecraft, at about 400,000 feet. The adapter section was already apparently starting to burn up, and beginning to leave a trail behind it before any evidence of an ionization layer trail behind the spacecraft was noted. The trail from the ionization layer behind the spacecraft was quite visible for a long distance behind the spacecraft, and the trim angle of attack was noticeable too, as the spacecraft angle to the trail. The horizon was visible until about a 100,000 feet, after which the spacecraft attitude became such that the horizon was below the window field of view. Drogue deploy, R & R separation, and main chute were all observed visually through the windows. The oscillations upon the drogue were observed to be both one of an oscillation of the total combination combined with a small relative oscillation about the connection point

between the drogue laynard and the spacecraft. Barostat lights were observed to come on at 40,000 and 10,000 feet and correlated closely with altimeter readings at the time.

FCSD Rep What do you estimate as the amplitude of your oscillation at this time, right after drogue deploy?

Armstrong Based on my observations of the attitude indicator, I estimated a maximum oscillation of approximately 40 degrees total.

FCSD Rep Plus or minus what?

Armstrong Plus or minus 20. While Dave's observations on the right indicated a somewhat higher value.

Scott Yes, I'd put it on the plus 20 side.

Armstrong After the main chute was observed to be in good condition, the cockpit mirrors were used to determine whether or not we were over water. The horizon was not visible at this time and the area between the water and the sky seemed to be quite hazy. However, it could be seen that we definitely were over ocean waves, which gave us license to go to single-point, or go to landing attitude from single-point.

Scott I might add in there that the point between main chute deploy and the actual reefing of the chute, when you

get about a two second free fall, that was a slight surprise.

Armstrong At this point we'd like to go back to the orbital part of the visual sightings and discuss the motion of particles relative to the spacecraft. These particles may be some particles originating from the spacecraft and may be particles drifting in space. They can generally be expected to be particles that had originated from the spacecraft. When moving from daylight to darkness or darkness to daylight, these particles become visible as was mentioned on most previous orbital flights. The Gemini VI crew first reported seeing these particles moving normal to the axis of the spacecraft, and parallel to the velocity vector, during their rendezvous; when they were several miles underneath the Gemini VII Spacecraft and pointed approximately vertically up. This same phenomenon was noted on Gemini VIII and it is very clear that if these particles are indeed originating at the spacecraft, then there's some sufficient drag at these altitudes to rapidly accelerate the particles away from the spacecraft in a generally downwind direction.

Scott Back to the landing that we discussed in the other tape, the impact and the relatively high magnitude. In addition to that, we felt the direction was closer to the X axis of the spacecraft then what you might expect in a normal landing attitude.

SECTION 10 EXPERIMENTS

10.1 Bioassay of Body Fluids M-5

Armstrong This equipment was not unstowed during the flight. The ECD's were turned over to the medical officer on the ship for incorporation into the experiment specimens. It should be noted here that the flight article UCVMS was first available to the crew two nights before the flight and did vary in configuration in several points from the training article.

10.2 Frog Egg Growth (S-3)

Armstrong Right hand seat unit number 1 was activated at 40:10. The right hand seat unit 2 was activated at 2:25:07 and the heater switches were turned on at that time and then the left hand seat number 1 was activated at 13:02:50 on the water.

10.3 Nuclear Emulsion (S-9)

Armstrong Nuclear Emulsion S-9 was activated at 23 minutes and was not recovered.