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GEMINI IX A

TECHNICAL DEBRIEFING (U)

June 11, 1966

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MANNED SPACECRAFT CENTER

HOUSTON, TEXAS

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PREFACE

This preliminary transcript was made from voice tape recordings of the Gemini IX Flight Crew debriefing conducted June 7, 8, and 9, 1966 at the Crew Quarters, Cape Kennedy, Florida.

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

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1.0 COUNTDOWN

1.1 Crew Insertion

Stafford — The flight crew insertion was performed in a smooth and efficient manner. It is our observation and analysis that the total flight crew countdown has a pad of approximately 20 to 25 minutes spare time. Approximately 5 to 10 of this is prior to the crew insertion and the events leading up to the sequence of lift-off has an excess of probably 20 minutes, in which the erector is lowered early and the White Room is broken up considerably earlier than is really required to meet the final T-0 schedule.

Cernan — I agree, Tom. From insertion to lift-off there was very little really that we did or that we were required to do in the thirty minutes. There was a great deal of slack time in this period.

Stafford — This was particularly true for the functions that were involved with the spacecraft, there was a lot of real dead time there.

Cernan — The only problem we had on insertion was during our first attempt at lift-off where we had some hatch, food pouch problems which were solved and we had no further problems with the hatch closing during insertion on the second two attempts.

1.2 Communications

Stafford — The individual systems checks were performed satisfactorily including ECS communications and static firing. We were kept up to date during both launch attempts by the spacecraft Test Conductor on the status of the Agena and the ATDA. This was good, we were in good contact with MCC Houston.

1.3 ECS

FCSD Rep — How was your ECS, were you comfortable in your suits?

Stafford — We were very comfortable in the ECS. We had suit fan 1 and 2 on for the whole time. Went to suit fan 1 prior to lift-off.

1.4 Launch Azimuth Update

Stafford — The launch azimuth update was non-existant on the second launch attempt with the ATDA which caused a scrub. The method used was very timely when we did not get the launch azimuth update on our final launch attempt and when we did fly.

2.0 POWERED FLIGHT

2.1 Lift-off

Stafford

The countdown to engine ignition was previously simulated and experienced. There was no doubt as to the exact sequence of lift-off because the noise and vibration decreased noticeably and you could feel a slight pulsive pressure on your back as the booster lifted off. Very slight. During powered flight the booster was smooth, the noise level was not excessive until we reached MAX-Q.

2.2 Roll Program
2.3 Pitch Program

Stafford

The roll program was on time and the pitch program was on time. The one major problem developed after going into Mode 2 delayed flight at approximately 55 seconds, the Sun came in the Command Pilot's window and completely obliterated all the control panel displays. Command Pilot was required to fly with his left hand on the abort handle and his right hand in front of the faceplate to try to shield out the sun. With this I could only see the pressure gages of the booster and again it was very marginal, what I could read. It was doubtful if there had been a failure, or a switchover, or even abort lights, that I could have seen this abort light. I informed the Pilot of this and had him relay the information to MCC Houston as to the status. Do you want to make some comments about the sun, you had it for awhile?

Cernan — Yes I had the sun probably a little bit before you, but I lost it a little bit sooner than you did. I did not have the problem monitoring the booster systems as you did. It bothered me but it didn't bother me to the operational extent that it bothered you. It was completely blinding, it just wiped out your whole cockpit.

FCSD Rep — What can we do about it?

Stafford — I don't know right now unless you'd launch with the poloroid type of filter on the outside and again it depends on the time of day that you lift-off and the time of year. Anytime there is the possibility that this occurs you could possibly have the Command Pilot wear sun glasses. To counteract the problem of sun in my eyes, which occurred at approximately

1 minute and 10 seconds after going into Mode 2 delayed flight, I placed my right hand over the faceplate and held it in front of my face throughout Stage 1 flight during which we developed slightly in excess of five g's, which probably accounted for some of the physical effort that was exerted during this time. The sun remained in a bad position until approximately 2 minutes and 50 seconds. At this time it passed out of the left corner of my windshield and was no longer a problem. However, it did take another 15 to 20 seconds for my eyes to become acclimated to the inside lighting conditions of the spacecraft to read Stage 2 gages. If a malfunction had occurred during the staging sequence I would have not been able to see this. I would have had to be informed of this by the ground.

2.4 <u>ECS</u>

Cernan — The ECS performed real well on boost, the cabin started sealing very early and sealed just prior to 1 minute.

2.5 <u>DCS Updates</u>

Cernan — We received no DCS updates, we expected none and we were told by the ground that we would receive none.

2.6 Engine 1 Operation

Stafford — Stage 1 engines performed very smooth and very efficiently with a nominal g profile and pitch program. There were no rates at all during Stage 1.

2.7 POGO

Cernan — I didn't feel any pogo.

Stafford — There was no pogo whatsoever.

2.8 Staging

Stafford — At staging even though I had the sun directly in front of me and my hand there, I could see the orange fireball with the black ring that developed out of the left corner. It came instantaneously and disappeared. However, I could not see this as distinctly as I'd observed it on Gemini VI due to the fact that I was concentrating inside the cockpit looking at the gages. It still flashed out of the corner of my eyes.

Cernan — From the Pilot's side it didn't appear to me as a fireball that we flew through like I really expected to see or that the Gemini VI crew had seen. It was a rounded orange sheet of flame impregnated with black smoke that sort of appeared out the right side of my window. It just appeared and disappeared all in one motion.

Stafford The total staging sequence was nominal.

2.9 <u>RGS Initiate</u>

Stafford RGS initiate was on time and a very low deviation, as far as the yaw and pitch needle.

2.10 <u>Steering</u>

Stafford The steering came in very smooth.

2.11 <u>GO/NO GO</u>

Stafford The GO/NO GO was on time from Houston and we gave a GO. This was at 4 minutes and 25 seconds.

2.12 <u>Systems Status</u>

Stafford All systems performed very well during boosted flight.

2.13 <u>Acceleration</u>

Stafford The acceleration built up to approximately an indicated 7.1 g's at SECO. During the later part of accelerated flight from approximately 5 minutes on the Pilot noted that the RGS errors were starting to build up and I glanced over and could see them.

Cernan — There was positive RGS, there is no doubt about it. Prior to SECO the RGS pitch error was about zero. But yaw started to build up very slowly. I don't recall what the maximum was at SECO but it started to build off in negative yaw very slowly. Again we were informed that this would probably happen because of the lack of updates and it was a slow IGS yaw error build up.

FCSD Rep — Tom, do you think that this window cover that you had, helped?

Stafford — I'm going to cover that at SECO.

Cernan — Let me add one comment on the systems. All the systems were checked that could be checked either by gages or those that could be cycled such as the OAMS source pressure, all the propellant systems were checked. All the voltages were checked twice prior to BECO and they all were GO. These were checked once prior to SECO and they were all GO. The AMU temperature and pressure remained at its pre-lift-off configuration throughout the whole powered flight.

2.14 SECO

Stafford — At SECO, we were expecting and did see anomalies in the IVAR routine. Powered flight ended at

5 minutes and 40 seconds, which was a few seconds in excess of what we expected. I counted down the seconds orally after 5 minutes and 30 seconds so we'd know exactly when SECO occurred.

2.15 <u>Communications</u>

Stafford

Communications were good throughout the powered flight. At SECO plus three seconds the IVI's counted up and immediately showed us that we would have a large out-of-plane number as we would expect. Associated with this were large velocities fore-aft and up and down.

3.0 INSERTION

3.1 Post SECO

Stafford

It was immediately evident that we had a small amount of velocity to be added to achieve our desired orbital velocity of 25,740 feet per second. When rolled out to a 0, 0, 0, attitude the first fore-aft indication showed 60 feet per second forward required. Now this was due to the slight 1 to 2 degree error in yaw and the large yaw component that was required in the IVAR's. The total velocity vector was corrected by the Pilot reading out address 95 and 72 and burning. At SECO until the spacecraft separation at SECO plus 30 seconds there was no noticeable rates developing in the total Stage 2 spacecraft combination. Total vehicle was very stable.

Cernan

Separation and fairing jettison were normal. I feel that the whole separation sequence was extremely nominal, extremely repeatable from what we'd seen in the simulator.

Stafford

Before the window covers were jettisoned I noticed that the outside window cover had a deposit on it. After jettison of the window cover it was immediately evident that the outside of the spacecraft window screen also had a deposit on it that was somewhat similar or possibly in excess of what was experienced on Gemini VI. Prior to lift-off and on all the spacecraft preflight checks those three panes in the spacecraft hatch window were nearly optically pure. As the flight progressed a white smudging smear deposit developed on the inside of the outer pane, and you could definitely see the thickness on the outer pane. The outside had a regular grayish smudge deposit on it - blackish-gray smudge while the inside over the - as the flight progressed-slowly built up to an increasing white opaque smudge in an irregular pattern. On reentry this turned into a hexagonal crystal shaped material - on the inside of the outer pane. It is still there on the spacecraft.

Cernan — One thing that might be said for the window covers, that was questioned before we lifted off, was the force required to jettison these covers and it was more than adequate because window covers just zapped away very rapidly. There's no question about the fact that they were going to leave. The Pilot's window also was dirty, smeared - prior to window cover jettison and maybe part of that smear, or visual restriction, left with the window cover; but the majority appeared to be there and I had smears, particularly within about 2 inches around the perimeter of the window. It was extremely smeared or coated in that area around the perimeter about an inch and a half to two inches inside the perimeter all the way around.

Stafford I noticed this also - the center was more clear than the outside.

4.0 ORBITAL OPERATIONS

4.1 Platform Alinement after Insertion

Stafford — The platform was alined very rapidly after insertion. The primary scanner showed a close alinement to what was anticipated for the -0, 0, 0 position on the spacecraft axes. The secondary scanner check was made. The secondary scanner agreed identically with the primary scanner. The Horizon Scan Mode of operation was not checked until later in the flight, however the Horizon Scan Mode of operation proved very satisfactory and the secondary scanner provided the increasing reliability at sunset and sunrise and also extreme cloudiness over the primary scanners. A qualitative observation was a fact that the secondary scanner may have been slightly more accurate than the primary scanner. The secondary scanner was used for the majority of the alinements for all major burns.

Cernan — There was a communications check that went real well. UHF No. 2 rang in loud and clear and there was no HF check. We had not planned to make one at that time. As a matter of fact, we never did use the HF even on the surface after landing. We never tried to extend the antenna at all. Going into the Phase-Adjust Maneuver Update, it came up twice, and it was updated, and the final update was a good one and it was burned, and our residuals were nulled very easily. We had 80 as plus 1, 81 as plus 2, and 82 as zero.

Stafford — Those are all tenths of a foot per second.

Cernan — Those are all tenths of a foot per second, that is correct.

Stafford — And these were made very easily just to null them to this and no excess time was spent in getting down to this low value as far as residuals. The Carnarvon pass was carried off nominally with the radiator going to FLOW, the 16-1 was GO, Accelerometer Bias Check, the 250 Nautical Mile Update and the Cryogenic Read-outs. Immediately after the Insertion check-list was completed both the Command Pilot and Pilot removed their gloves and installed the wrist dams. Helmets were removed and stowed with the gloves in the Helmet Stowage Bags after the 16-1 Update passing Carnarvon.

Cernan — And after we passed Carnarvon we then began to go through our Post-Insertion stowage list which for rendezvous - primarily for photographic equipment prior to rendezvous and it went very smoothly and the stowage of the equipment, and the sequence in which we unstowed the gear was very smooth.

Stafford — The first difficulty of any system we encountered occurred approximately 1 hour and 30 minutes, and this is when the optical sight was checked with the power cord from the lefthand reticle, and it was noticed that I had no light visible in the optical sight. I rechecked all the connections and found that the base of the connector to the Auxiliary Recepticle was loose. However, my camera would work, which shows that I was getting power out of it, and occasionally I went back to the small light, and this would work intermittently. Because of the short time available to have the Reticle ready for NSR, we stretched the power cable from the Pilot side across the cockpit to the reticle and continued this for the two rendezvous that day. We did not have time to change it. We did not want to make a serious electrical connection which could possibly short out the Reticles, since it was extremely important for these rendezvous.

Cernan We felt that once we had the sight and M-3 was of such high priority that we wanted to maintain the sight and the fact that this cord stretched from the Pilot's Recepticle to the optical sight really did not hamper the Back-up Rendezvous routine nearly as much as first we thought it might. It really did not interfere much at all. Although it was noticeably stretched across the cockpit. You might just as well go into that, tell them what we found out about it.

Stafford After we were able to troubleshoot the connections and the cords, it was determined that the power lead on the lefthand Recepticle was inoperative. So, we switched cords.

Cernan The cords at the Recepticle.

Stafford Right, we switched cords during the rest period at the end of the first day's activity, so we would have a good power lead over on the left side for the camera and the Reticle, and have just a good camera on the right side. This alleviated the problem.

Cernan — And that cord operated the camera on the Pilot's side without any problems as it had on the Command Pilot's side, and the other part of the cord worked intemittently; so we feel that there is possibly some short either in the cord itself or in some of the contacts within the recepticle part of the cord. We did not have a Height Adjust update - this was of a magnitude of 14.6 feet per second - we were updated once - we burned and all residuals were nominal and the burn was on time and went well. We had 81 percent fuel remaining at the end of that burn.

Stafford — You want to give the residuals for the Ncc?

Cernan — Yes, Ncc - I'm looking back at it - I believe they were all zero. Our first cut at the residuals - we did have a little - our first cut gave us 80 of minus 2 tenths of a foot per second, 81 of zero, and 82 of zero and then we punched these up twice without any burn each time we took the residuals, and the second time there was a little bit of overlap and they all came out zero.

Stafford The Vector to be applied then was 14.6.

Cernan Fourteen point six feet per second; it was 67 degrees yaw left and 44 degrees pitch up, using the aft thrusters. It was a northward and upward pointed burn, and the burn went on time and nominally. No problems nulling out residuals at all.

Stafford At this time we had 81 percent fuel remaining, after the burn.

Cernan We might add that right through all these first two burns, we'll make this comment because of what happened at the NSR burn, but the computer particularly the Catch-Up mode and the Start Comp cycle of the computer worked nominally. No problems with it at all.

Stafford Next item occurred at 2 hours and 12 minutes at Tananarive. The lock on was first obtained on the ATDA at this time and we were on a 0, 0, 0. The lock on light flickered. Attitude needles were very wavy, however during periods of lock on the range appeared very solid and decreased in the manner that was expected. The update for the Coelliptic Burn was received and the address inserted into the

[redacted]

computer.

Cernan

The Coelliptic Burn was 54.0 feet per second burn. It was made in a 3 degree yaw left attitude and 41 degrees pitch down attitude, made in Rate Command.

Stafford

All previous maneuver burns were made in the PLAT mode.

Cernan

It was right on time and we again had no problems in nulling residuals, 80 was 0, 81 was plus .1, and 82 was plus .1. It was made with the aft thrusters downward and northward.

Stafford

The first computer anomaly was noted at this time, and after Push Start Comp we noticed that the needles did not correspond - did not give the proper indication for the burn at this time. We went back to Rendezvous mode and then the Catch-Up and when we went from Rendezvous into Catch-Up the Start Comp light came on immediately. In the Rendezvous mode everything zeroed and the computer light went out. Then coming back in the Catch-Up, the computer light came on but the needles gave proper directions and the IVI's count up to the proper addresses - to the proper numbers. And this was the first

[redacted]

time we noticed that the Start Comp cycle was initiated without any pushing of the Start Comp button. We wanted to check it at this time and went back to Rendezvous mode, came back into Catch-Up and most of the same event occurred. However, since it was very near the time for burn, we did not change the Computer mode and and made the burn on time and had the residuals as noted.

Cernan I do not have a component quantity remaining written down at the end of this one.

Stafford It occurred when we were loading the computer and checking the numbers on the IVI's prior to NSR, but it was very close to NSR. We thought it might be some anomaly but we wanted to go ahead and check out the Rendezvous mode - and we went into the Rendezvous mode after NSR. At 02:25 the Carnarvon pass was nominal - went through the Cryo Quantity readouts and the fuel cell purge.

Cernan You might mention that during the fuel cell - during this and all subsequent fuel cell purges were all good. The fuel cells performed better than anything I had ever expected to see. The stack currents were all within a half an amp and 2 Charlie maybe dropped off to hold about one amp less than the others, but they were very evenly matched. The fuel cell purges went real well. I alternated on my own from Section 1 to Section 2 except when the ground requested either one or the other sections first. They were purged hydrogen-hydrogen, oxygen-oxygen in that order with the Cross-Over Valve on. The voltages held high.

Cernan — There were no problems with the purging of the fuel cells or with their operation, whatsoever. I think that they performed outstandingly and will probably not mention them during the debriefing from here on, unless there are any particular questions.

FCSD REP — Did you get Delta-P lights?

Cernan — Yes, there is one thing I did want to mention. I did not ever get a Delta-P light when I purged oxygen, but I invariably got a Delta-P light when I purged hydrogen, on both sides. The thing that was significant to me, was that when I purged hydrogen or oxygen with the Delta-P gage, I saw very, very little increase in the Delta-P reading when I was purging. Whether I was watching the Delta-P of the hydrogen or whether I was watching the Delta-P of the water, I saw very, very little change, much less change than I ever expected to see in this Delta-P gage, during the purges. This was true of both sections. Normal operation of hydrogen was about .6 to .65 oxygen to hydrogen and about 2.3, I believe, oxygen to water. When I purged hydrogen for instance, I got a Delta-P light, but it didn't increase the pressure very noticeable on the gage. It was barely noticeable, but I did get the light.

Stafford — The computer was switched into the Rendezvous

4.2 <u>First Rendezvous</u>

Mode at the programmed time and data points were collected and rejected. Every hundred second interval, the range was stowed as programmed. From this, we know we computed the Delta-Delta R's and during this time, the radar was occasionally breaking lock, but it was only momentarily, say about one to two seconds maximum and then back in. The needles were occasionally steady. In fact, they were more steady at that point than what I saw on Gemini VI and it stayed steady for a while and then take off on a bias and have a sinusoidal on the bias then break lock. This was what we expected to see from information that McDonnell Aircraft has supplied.

Cernan — We went into the Rendezvous Mode the first time and obtained our expected solution after the required number of data points. And after this first solution, the Start Comp cycle initiated just as if we had selected that data point. We then appreciated that this was a problem left over from what we had seen in Catch-Up Mode at NSR. We then reinitialized the computer and went back into Rendezvous Mode. As a matter of fact, I'm sure we went to Prelaunch at this time to let the computer make a self check and I'm not sure whether this first time, we actually turned it off and turned it back on again. But we did go to Prelaunch and went back to Rendezvous. All the correct addresses were put back in for the new solution. At the predicted time we received a second solution, and we had a repeat performance to Start Comp cycle. As soon as the solution came up after 8 data points, a start comp cycle was initialized. At about this time, we felt that we were probably going to have to go open loop. We went through this cycle once more and informed the ground of what our problem was, and they came back shortly thereafter with a time to go into Rendezvous Mode which would give us a solution after their predicted point C, which would be when we would want the solution. They gave us this time within about a minute or thereabouts of when we were to reinitialize the computer and go in Rendezvous Mode. We were actually about 12 seconds late in doing this, because we didn't appreciate the time was upon us. As it worked out, it was better that we were a few seconds late. We then knew the computer was working, giving us 100 second data points, and we still felt that we were going to go open loop, comparing open loop with the ground back up. To our surprise, the computer did, at the predicted point C that we came up with on board, come out with a solution and gave us a closed loop solution. Although the computer was initializing a Start Comp cycle of its own, and came up with the first solution after the 8 data points, we were not reading out very good angles, because the radar needles were not that good to give us good angles. But we were getting a very important parameter...we were getting range changes at the end of the 100 second interval which gave us Delta-Delta R which pin pointed our position to be just about 12½ miles without any ellipticity at all. Delta-Delta R stayed within minus .49, dropped maybe to minus .46 and then came back to .48 and remained at that prior to TPI. We felt that we were in real good shape with no ellipiticity.

Stafford The radar needles would usually become steady after acquisition of a lock on and then build up on a bias, with increased sinusoidal activity in needles until lock was broken and then initialize back very steady when lock on was obtained again. This cycle was continued. The amplitude of the excursions from zero was not quite that previously predicted. In fact, the bias would build up to approximately one degree in the sinusoid imposed on this added excursion was not in excess of plus or minus one degree. During this time, one thing that was not predicted was the way that the analog range rate meter fluctuated. They would steady down for approximately 2 seconds maximum near the proper value, then go full scale positive and then bang into full scale negative and then come around positive. Complete the cycle several times, settle down for a second or two and then go positive, then negative continuously. This occurred throughout the time that we had radar lock on in any position with the ATDA from maximum range down to 50 to 60 feet.

FCSD REP: Did this get worse as you approached the target?

Stafford: No, the intervals of the sequence of breaking lock became less and less as we came closer to the target. From approximately 25 miles in, we only occasionally had a breack lock.

Cernan: I have a note here that radar was turned on and lock was intermittent at 130 miles. And fairly solid at 120 miles. Now this was just lock, this was not needles. We found out on the third day when we were moving away from the ATDA that we actually had radar lock up to 179 miles.

4.3 Terminal Phase Initiation

We felt that we had no ellipticity, and we were just short of 12½ miles. The ground gave us backup Terminal Phase Initiation information which we felt was very good with the one exception that their time appeared to be a little bit early from what we decided was our Terminal Phase Initiation time based upon our angle change. As it turned out the ground gave us 26.7 forward, 1.3 up and 2.2 right. The computer, which gave us the solution at the right time, came up with 26 forward, 8 up and 4 right. Backup solution came up with 24 forward and 0 up-down and of course, we did not get any left right on the backup solution. Looking at the three solutions, we felt that the closed loop was obviously to us wrong with this 8 up correction, so we went ahead and used 27 forward, 1 up, and 2 right. This is somewhat of a compromise between the ground and the backup solution. The Computer Start Comp light for the predicted time of burn was exactly on time. Backup information said that we should burn at 12 minutes and 50 seconds elapsed time. This had gone around through 60 minutes from NSR and we burned. This might not be exactly from NSR, because we did reinitialize the time a couple of times because of the computer. But anyway the Comp light came on exactly as predicted, we burned on time and Terminal Phase Initiation went nominal.

4.4 First Sighting of ATDA

Stafford

The ATDA was first picked up in the reflected sun light in excess of 50 miles. It appeared as a small speck of something like a speck of dust, floating around in a lighted room. It could be comparted to approximately a fifth magnitude star. Just minimum visible and the dimmest light I could get on the reticle. When it would go into the markings on the reticle, it would disappear completely. As we came closer to the ATDA, the magnitude of the light increased and from approximately 30 miles on in, it was visible all the time and we had no trouble seeing it in the reticle pattern.

Stafford — At this time I noticed the difference between radar bore sight and the reflected light in the optical sight. The difference between the radar bore sight, when the radar had achieved a good solid lock on, and with no sinusoids in it, it appeared the error between the two was less than plus or minus a quarter of a degree, which is far in excess of what we've ever had before as far as accuracy. The total sun light condition as provided from the ground phasing appeared to be extremely accurate. We were able to transfer on the target in reflected sun light and also make the first back-up correction measurement in one to four minutes after transferring in reflected sun light. The ATDA appeared in the darkness approximately 5 minutes after transfer. The ATDA built in intensity to approximately a zero magnitude star. It was not as bright as spacecraft VII that I had seen on the Gemini VII and VI mission.

Cernan — The first correction came out to be quite small, which was gratifying.

Stafford — This proved that the solution we selected for transfer was very accurate since the first correction was very small.

Cernan — That's right. This was first indication that the closed-loop solution for Terminal Phase Initiation, particularly the eight up that it gave us, it was a good thing we did not burn it. Our back-up solution for the first correction gave us two aft, and three up. We did not burn it because we had the closed-loop solution cranking and it was verified during this first back-up correction through address 69. We were cranking out a closed-loop solution at this point. So we decided not to burn the back-up and to see what happened after the second back-up correction at which time the closed-loop also gives a correction. We figured the closed-loop was good and looked reasonable, then we would go ahead and burn it. The closed-loop solution then, which corresponds to the second back-up solution, gave us a solution of two aft, two up, and three right. The back-up solution said three aft, and four up. We burned

Cernan — the closed-loop solution all the way down the line because it and the back-up solution agreed very closely. As a matter of fact they both indicated that the first back-up solution was a good correction. They complimented each other as corrections, and they again indicated to us that the closed-loop Terminal Phase Initiation of eight up was not a desirable TPI solution. Going on to the third correction, which is a back-up correction, without any close -loop, we had one aft, and one up, we burned zero.

Stafford — Since we stayed closed-loop.

Cernan — Since we stayed closed-loop. The third back-up correction is just sort of a predictor as to what the closed-loop might give you. This along with the relative trajectory plot, which looked very good, had us inside, well we started inside, at $12\frac{1}{2}$ miles, 12.3 miles or there about, held us inside all the way up the pike. Continuing with the correction. The fourth correction, closed-loop gave us 3 forward, and 2 down. The back-up solution said zero

Cernan — foreward and 3 down. We decided to go ahead again with the closed-loop correction, and we burned 3 forward and 2 down, and there was zero left right, in this solution. It appeared to be a good one, it was again complimented by the back-up solution and by the trajectory plot. It was a small correction, which was important. We felt it should be because of our plot. It turned out to be a good correction, because line of sight control, after the fourth correction, turned out to be built around plus or minus four degrees a minute, which we checked every 30 seconds. It didn't vary enough to really warrant putting any line of sight control in. In other words that fourth correction, nulled any line of sight control problems we had. There was no problem at all controlling the up and down as we rode in to braking.

Stafford — As previously noted the ATDA disappeared from reflected sun light at approximately 5 minutes after TPI. Immediately after going into darkness, while the spacecraft was still approaching

Stafford — the darkness line, we saw the flashing light. The flashing light stayed on approximately 15 seconds and disappeared. This can be contributed to the rotating attitude of the ATDA.

FCSD REP — What was your range when you first saw the acquistion light?

Stafford — The range was at approximately $5\frac{1}{2}$ minutes after TPI, which was approximately 20 miles. As soon as we went into darkness it was there. Now, the Acq light continued to appear and disappear in cycles that could be contributed to the rotation of the vehicle.

Cernan — Acquistion of the Acq lights gave us, what we thought was a clue, that the shroud was not there, because you could see very brightly the flashing Acq lights. They were flashing intermittently between the angry alligator jaws, and the side of the TDA cone. They were ample as flashing lights, even with the restriction of the shroud.

Stafford — We had both acquistion lights working and were in a position, with respect to where the shroud was attached, to see the acquistion lights.

FCSD REP — In spite of the fact that you were not dark adapted and the cover was still on, you could see them at 20 miles.

Stafford — Right.

Cernan — We saw them, I feel very soon after it got dark, as soon as we got acclimated to darkness.

Stafford — I was watching through the reticle for optical sight, and as soon as the ATDA disappeared from reflected sun light, within 30 seconds I had an Acq light. Like that.

FCSD REP — You could probably see them further out.

Stafford — Definitely. And this appeared as approximately a third or second magnitude star at that distance. As we continued in, at approximately 8 to 10 miles, the major change in lighting parameters was the full moon. The ATDA tracked down with respect to the stars, to a point where it became inertial. At this time, this coincided with the moon when it came up and it was very near stationary to the ATDA. In my optical sight, I had the ATDA centered and to the right approximately 5 degrees was the full moon. In the reticle pattern I only had one

Stafford star. Looking outside the reticle pattern, I could only count three other stars because of the ambient lighting from the moon.

The rest of the Terminal Phase to the final braking and up to the point of Station Keeping was made with the ATDA next to the full moon. It presented some constraint for tracking because of the absence of stars. It helped in one way because the whole ATDA became very brilliantly lighted from the moon. At approximately 4 to 5 miles I could ascertain colors, small minute colors, which were the running lights on the ATDA. I could definitely see these little red colors at this period of time. As we got in closer, you could then see the amber and then the green colors.

We had a slight Out Of Plane star, after the last mid-course correction. I made one maneuver with the lateral thrusters and it killed it to zero. We continued all the way to braking.

We had one braking at approximately .9 of a mile.

Cernan — At 26 minutes after transfer we were exactly at 2 miles, we had an elevation angle of 99.0 degrees. Nominal at this time is 97. We had a range rate of 37 feet per second. Without going into the other points in and around, before and after this, I'll just pick out one mile. At 29 minutes we were 110.1 degrees, which shows that we were almost inertial, and were at .98 miles and 32 feet per second. At this point we had already zeroed addresses 25, 26, and 27, so we pushed Start Comp and we took off 12 feet. We actually took off 13 feet per second, and we had 19 feet per second from that point on in.

Stafford — By the time the total burn was made, we were down to about .75 miles with approximately 20 feet per second. We held this to approximately 5,000 feet at which time we broke down to approximately 15 feet per second. From that point on we continued to 1,000 feet and reduced it down to 10 feet per second.

Cernan — We ended up with 58 percent fuel remaining at approximately 50 to 60 feet. The whole

Cernan	rendezvous from TPI in, was extremely comfortable. Braking was very comfortable. The sextant was not evaluated on this rendezvous although it was readily at hand for braking if it were required.
Stafford	The first indication we had that the shroud was still on the ATDA was when we saw the cone lights and we could determine the "V" in the docking cone. We noticed then that we didn't have a complete circle for the docking cone. It was just a small wedge shape area under these lighting conditions.
Cernan	It was dark at this time. I turned off the Acq lights when you told me to. I guess we were very close, but it was still dark.

Cernan

Running lights for attitude determination did not help at all. You could see the running lights readily. You could see the split in the running lights, but since the vehicle was tumbling, it gave no attitude references at all, either for station keeping or for nulling line of sight. Nulling line of sight was strictly done on the ball, on the 8-ball of the spacecraft.

4.5 Station Keeping

Stafford

As we passed from night into day time, it was then fairly easy to station keep on the ATDA by keeping the X-axis of the spacecraft alined with the local horizontal and also alined with the center of mass of the ATDA. It appeared that the ATDA had a roll rate slightly in excess of approximately 2 degrees per second and very small rates, extremely small rates in yaw and pitch. Over a period of time these would couple where at one time of the ATDA would be rolling horizontal, and over a period of time it would go up to where it would be rolling about a vertical axis and then later on about a 90 degree yaw axis. This would just take place over a long period of time, the way

	the axis would couple. But the grip fault motion was always in roll.
Cernan	Tom, while you are talking about the roll rates of the ATDA, in case we neglect to cover it later, it might be worth while mentioning the inputs of the TSSI, stablization, this type of thing that we saw when they did command it on.
Stafford	I think we will cover that when we get ---
FCSD REP	That is the next one here, I believe.
Stafford	Well, TSS Thruster, we did not observe this. These were not turned on at this time.
Cernan	Later after the third rendezvous, but I don't know whether it is covered in this -
Stafford	At this time, we gave a description to Hawaii. We told Carnarvon that the shroud was on. Then we gave a description to Hawaii exactly as to the configuration of the shroud. In moving into close formation the Station-Keeping with the L-Band antenna, we moved within approximately 4 to 5 inches, and we could observe the two coil springs between the aft segments of the shroud. The strap was held together by the wires that came from inside

the shroud to the connectors initiating the explosive bolts. Both explosive bolts on the shroud had fired, but the total mass was held together by these four connecting wires that fired the pyro devices. When we came across the States, the command for Unrigidize was initiated and at this time the total shroud moved on the ATDA, it appeared, in a pitch action of approximately 15 degrees. The total shroud and the angle between the halves of the shroud did not change, but the whole shroud moved down and then back when the adapter unrigidized and rigidized. At this time the real time decision was made to go ahead and initiate the second rendezvous for the equal period orbit with an Omega T of an 80 degree transfer orbital phase. Well, the time we had available for a platform alinement was very small, so we made a real rapid platform alinement while station keeping with the ATDA and then got into position directly on top of the ATDA which was a rather consuming task since it was a rotating body and pitch down looking directly to earth, we had to correlate between the position on the 8-ball and the attitude indicator and the ATDA. We arrive in a zero foot per second position at approximately one minute prior to the burn. A burn of 20 foot per second up was made on time and the residuals were nulled close to zero.

Cernan — The residuals were zero. I don't have them written down here, but I know this particular burn, the residuals were zero because we were concerned with getting a very accurate separation burn.

Stafford — The ATDA immediately went below us and in front of the spacecraft. We did make some plots using address 36 and 96 on the Progress Center Coordinate Plot and the ATDA, at this time was close, was readily visible on the earth below since we were approaching sunset and the earth was not brightly lit up. The flashing lights were turned on, were visible, but also at periods of time, the ATDA was rotating after it went into the darkness we could see the red lights, the red running lights on the ATDA in excess of 8 miles. You could see a small red dot out there at night time in between the flashing blue lights and the acquisition lights. When those were not available, we could see the red running lights at approximately 8 miles.

Cernan

Sextant practice was initiated. It was good practice, but no results were really obtained and the main ... no direct results of sextant readings were retained. However, the results that we got from it was that you cannot track a vehicle very readily, especially with the small field of view of the sextant, when you are looking down at the earth. In seeing a target that was, even the shroud on, that was as bright and white as the ATDA was, it was almost impossible to see the target against the ground background. It was impossible to see the target against a ground background. As a result there were no sextant readings taken during sextant practice. It was just impossible to acquire the target even through the reticle or through the open window without narrow field of view of the sextant.

Stafford

I could barely see the - when we first initiated, I could see the target because it was white, particularly with the nose shroud down against the dark earth and then as darkness came on, it disappeared rapidly. The flashing light was available, but also the horizon was so ill-defined at this time it was impossible to get any sextant sightings.

Cernan — When we went into darkness, however, we did get the target horizon crossing 30 minutes after burn nominal time was 30 minutes. So we felt our burn was pretty good. I took a sextant reading at 12 degrees to give us a preliminary backup to our horizontal adjust maneuver. Nominal was 41:05, our time was 41:22, which made us feel pretty warm. And then we did get a GET of local horizon crossing of 45:20 and 45:33 was nominal. This gave us a Horizontal Adjust Maneuver of 0.1 foot per second forward and 0.2 foot per second out, which ended up in time to be zero forward and 0.5 foot up at which time we made a decision not to burn.

Stafford — We feel that the regular separation maneuver was performed with precise accuracy and skill.

Cernan — Terminal Phase Initiation, the Pilot was all set to take his sextant reading, his ball readings

4.6 Second Rendezvous

and complement them with radar and range rate reading. The first sextant reading to be taken was 43 degrees. However, the sextant was taken in a second sextant reading was to be 47 degrees. And the use of these two angles, plus the time, plus the change in our angle as read off the 8-ball was to give us a transfer maneuver. But instead of setting in 43 degrees, 47 degrees was set in initially. And it was not realized that this was the second angle until after this angle was taken. As a result we were late at that time of transfer. So we regrouped and I computed the change and angle on the ball for a period of time, went into the charts knowing that we were now late at TPI. Going into the charts with Delta Theta from the ball, ignoring sextant angle for a minute, and in time we came out with a TPI solution that said 2 aft and 3 down. The nominal solution should have been 3.6 aft and 2.8 down. We initiated immediately because as I say, we were late and this regrouping did take a little time. As a result of being late on the TPI our next sextant reading was to be 56 degrees. We had just passed 56 degrees, when I took the sextant up to find out what angle we were at. It takes just a minute or so to get your sextant set to take it. To acquire the target, to pick up the horizon, to take your sextant measurement, take the sextant down, put it under the light, and read it to find out exactly what this angle is; this is a time consuming operation. When I read it, we were at 57 degrees, so I said I will again ignore the sextant readings at this point and take our correction of Delta Theta from the ball and time. So the first correction was made on basis of Delta Theta and time and not the sextant. The sextant however, at these angles 50 and 60 degrees was still very usable. And the reason I lost the sextant correction was a result of being late at TPI and being cramped for time. I came up, however, with an aft correction of 0 and up-down correction of 2 down. Now this looked as our plot on the target center coordinate graph showed us. Even though with a late TPI in this correction, we were right on the football and we looked real good at this time. The third correction was made on a basis of sextant readings and Theta on the ball. A Delta Theta from the 8-ball. The sextant readings were taken at 72 which was I consider a good sextant reading and the other sextant reading was taken at 80 degrees which I consider, not only in retrospect but I considered in real time, that it was probably not a good reading. The reason it was not is because the angle was so great that the only place you can take this sextant reading is from the lower left hand corner of the spacecraft window to see the horizon. You get a very small arc of the horizon and you cannot really tell whether you are holding the sextant vertically or not. This results in an error, maybe an appreciable error. So I consider about 70 or 75 degrees, 70 degrees maximum usable angle at which you can go after horizon target sextant reading. But I did come up with a solution of 0 fore-aft and 2 down. Now, I made a comment at the time we burned this, that this maneuver was bad, based upon that second sextant reading. I was not sure of it, but I felt that I owed it to the sextant to make this burn. So we made it as it came out, and it turned out to be a bad burn. Really our reading should have been zero. We didn't even need that third correction, that second correction. It should have been zero but as I said, I felt I owed it to the sextant to go ahead and put this burn in. I definitely feel that it should have been zero because as a result of this burn, our line of sight control, or inertial line of sight control, in utilizing the 8-ball, we were continually forcing up corrections.

Stafford — Up with respects to local vertical, down with respect to the spacecraft.

Cernan — No, up with respects to the spacecraft, we are --

Stafford — Okay.

Cernan — Our up and downs are always with respect to the spacecraft. All these corrections are with respect to the spacecraft. Our second correction said we should go down which would make us less steep for crossing the angles less quickly and our line of sight control after this correction said, - in other words we got inside the target, inside the football,and our line of sight control said we should force ourselves up or down and outside the football. It was a bad correction, but it was a small one, so it didn't hurt us too much and we picked it up very quickly with line of sight control and from there on to the rendezvous.

Stafford — Was made optically all the way.

Cernan — Was made optically all the way and there were no problems at braking. We did use address 25, 26, and 27 utilizing that we considered was an approximate range rate, just so we knew exactly how much we would take off in terms of range rate. If we took off 5 feet per second, we knew we had exactly 5 feet and not 7 or 2. And we did utilize this technique again in braking. We wanted to take off 2 now or 5 then and it worked out real fine.

Stafford — Let me cover the optical points of the rendezvous. After the horizontal adjust in which we had the platform alined 0, 0, 0 we noted the time when the flashing light crossed the zero position in the reticle, this was very nominal. After we broke out in sunlight, the ATDA disappeared completely. I monitored position on radar needles. I could not see it at all even though it was approximately 9 to 10 miles in front of us. After I rolled inverted, it became immediately visible, which showed that the lighting from the sun into the spacecraft window, the ambient lighting obscured the ATDA. When I rolled inverted at that position, the ATDA immediately popped into sunlight as a very brilliantly lighted body, which I would estimate greater than a minus 2 magnitude star or in other words it was more brilliant than Sirius, at this distance. It continued to grow in intensity. However, the growth was very slow until we got into approximately 2 miles. At this time the ATDA was still a circular glowing object. At 2 miles it grew more and finally in excess of one mile, we checked it with radar. I could take on the shape of the ATDA. Now the most lighting was obtained from the white nose cone or the shroud. At one mile I could ascertain the total shape of the ATDA, this was in the inverted position. I was going small end forward, inverted, pitched up at approximately 70 to 80 degrees and I could ascertain very well when I had one mile optically. Even though the ATDA was rotating in various attitudes, I could determine approximately in optical units on the reticle the length of the major axis of the ATDA and thereby relate to length the major axis to the unit of the optical reticle from this; making a good guess as far as range. You could definitely determine that we were closing on the ATDA and from just a basic roll trajectory, we zeroed address 25, 26, 27, made a definite braking maneuver and from this we would judge we had so much left. Now I left the range rate high to insure that we would arrive at the point of intercept prior to sunset. And the final braking was made with no difficulty and the ATDA was lighted brilliantly in sunlight throughout the whole maneuver.

Cernan — And I think that this rendezvous here shows the way that the lighting conditions should be for a passive target before an optical rendezvous. It worked out very well in the way it was predicted.

FCSD REP — Your pitch and yaw rates were pretty low on the target.

Cernan — The pitch rate was increasing all the way through during the mission.

FCSD REP — You're talking about the target?

Cernan — I'm talking about the target. It's the same as it's always been it was never touched from initial rendezvous until now; they just never varied. This pitching and yawing and rolling.

Stafford — But the main thing was that the roll was very, very slow even though 2 degrees per second; and at one mile I could ascertain the total outline of the ATDA, but I couldn't ascertain the RCS and the Battery section, but I could ascertain the main body unit of the ATDA and the shroud of the ATDA at one mile and this attended approximately one half of an optical unit and this grew steadily and from this, I was able to judge distance, and very readily, without any magnification just in the reticle determine that I was closing and getting a ball park range rate.

Stafford The major items to be gained from this rendezvous are the facts that we have the fine results from the optical techniques for alining in the rendezvous for a passive target; and also for obtaining angle measurements. The most effective way is to keep optically boresighted on the target and obtain the pitch gimble angle from the computer, or the angle off the 8-ball and not use the sextant as far as determining angles. The only reason that you would ever use a sextant for this optical rendezvous would be in case the platform fails.

Cernan This sextant takes time to read and takes time to acquire, and the part about it is, you cannot...you have to take it away from hand-held, now this is hand-held, you just have to take it down and hold it in front of the light to read it, because it is very difficult to read and you don't want to miss it by a degree. You want to make sure you're accurate, so it's very difficult. The fact is, I feel that a sextant that was rigidly mounted in the window in this particular case with this particular sextant, even though boresighted, would have been more difficult to use. Matter of fact, it would have been impossible to use above about 50 degrees, because as I said, I had to go down to the lower left-hand corner of the window to get what I considered a good reading at 72 degrees. The reading at 80 degrees, I felt was bad when I took it; so we would have been very limited in angle measurement if we had a rigidly mounted sextant in the window.

FCSD REP Could you get range rate...Did you attempt to get range rate with the sextant?

Cernan With the sextant? No.

Stafford No, this would be a far easier task with a stabilized body than one that was randomly tumbling.

Cernan You can determine closing rates again by splitting the image and closing, but the specific range rate numbers with this type of body would be pretty difficult to get, but I feel, that one thing of importance came out of this was the fact we were able, although late, we were able to regroup at TPI utilizing Delta-Theta from the ball and still have what appeared to be a good transfer and from the plots and a correction it was a good transfer; so we did not incorporate the sextant angle measurement in that particular maneuver strictly from the ball, and the ball and time gave us a good TPI.

Stafford — The station keeping was again obtained at approximately 60 feet on the ATDA. We moved in very close, within a couple of feet of the ATDA again like we had previously, obtained some more pictures and then we were informed by the ground that we would have a Separation Maneuver to perform the rendezvous from above using the Omega T of 130 degrees early the next morning. The platform was again alined and the retrograde motion was put in.

Cernan — The total velocity was 3.7 feet per second retrograde, our residules 80, 81, and 82 were all zero. The ground sent us up as using the forward firing thrusters in a retrograde motion, but we were in such a position that it was much more convenient to use the aft-firing thrusters in a retrograde motion because we were BEF so that was what we did, and there was a short burn so we figured there was no thruster life-time involved. So we burned 3.7 feet per second retrograde with the aft-thrusters. All residules were zero.

Stafford — Our next burn was the burn for our sleep period.

FOSD REP — Do you have any feel for what might have happened had you been simulating or doing a $2\frac{1}{2}$ mile Delta-h, you would have been 7 miles and if you had some slip when you reached the transfer angle whether this would have affected the visibility?

Stafford — I don't think the slip in the transfer angle would have affected the visibility. The major item that would have occurred if you would have performed a passive rendezvous from $7\frac{1}{2}$ miles was the fact of the high closing rates you can have, and also the variances in the closing rates that you can have from the situation, however, by definitely seeing a target of this dimension in excess of one mile, in reflected sunlight, the actual dimension of it can be ascertained the approximate range when you hit one mile. And you will know within say 20 feet per second that your total range rate is going to be approximately 50 to 70 feet per second, and at the time well say 40 to 70..at that time reduce the range rate 20 feet per second using the computer. You can readily tell that you are still closing at $\frac{1}{2}$ mile. Knock off 10 to 15 more feet per second using the computer then if it closes in to $\frac{1}{4}$ mile, then you can very accurately determine what your range is with respect to the deceleration capability that we have with the Gemini spacecraft.

FCSD REP How close was the sun line of sight to the target?

Stafford — Well, the sun line of sight to the target was -

FCSD REP — Was it below the nose?

Stafford — The closest the sun line of sight to the target was right after we rolled the spacecraft inverted at approximately one hour total from the Radial Separation Maneuver and, 10 seconds after completing the roll to 180 degrees position the ATDA came in reflecting sunlight brighter than a two magnitude star. It became more brilliant than that and as the sunline was less than 25 degrees. Once we had the nose of the Gemini blocking the sun, then the ATDA became brilliantly lighted and it grew intensely all the rest of the way through. In the final phase, we were pitched up approximately to 80 degrees, there we never had any problems with the sun. The main thing is to be sure to keep the nose of the spacecraft between you and the sun throughout the maneuver and I'm certain that you can see the other vehicle in the reflected sunlight out at a fairly long distance. Another important point that should be reemphasized is that if

	a good platform is available to the crew, they should take the pitch angle off the platform and not use the sextant. Continuing orbital operations, we covered the separation maneuver the next item was the CSQ pass where we copied the planned landing update and powered down the spacecraft. At this time, we had our first meal. Actually this was several hours and [illegible] minutes after the first rendezvous was completed in space and to keep initiated, we started to split a meal and eat a few of the bitesize items and drank some water. During the Passive Rendezvous, we managed to eat a few more bites and we were pretty well fatigued at the end of the second rendezvous in station keeping. Again, we started eat period 8 hours to 9 hours and restowed the spacecraft with required configurations.
Cernan	Fuel- cell purge went nominal as all others did. S-12 was opened at 09:29:00 GET. We did not hear the door open. And it was closed at 17:10:00 GET and we did not hear the door close We did not lock it at this time.

Stafford — Sleep period was initiated on time, however, even with the window shades up, it was very difficult to start sleeping at this time. It was more of an intermittent dosing period which can be borne out from the ground readouts of the heartrates and also even more than the ground readouts of the heartrate our own qualitative observations of the sleep. I would say at the most.

Cernan — Due to the same thing.

Stafford — Back to the ground time, we're used to, we've had the required amount of fatigue it takes to start sleeping, but it appears that it was impossible for us to go to sleep at this time. The next two nights, we both took two APC's prior to sleep and slept very good. As my recommendation as far as my intention as to the next time I fly, is on the first night, I will take one or two APC's prior to sleep and will probably have far better results on sleep. At the most I can say, I get forty-five to fifty minutes of partial sleep, wakeup, 45 to 50 minutes of sleep. Now one thing that could be noticed even though we had solid aluminum window covers around the edges; everytime we'd drift into the sun, light would come in and the whole cockpit ambient lighting would increase. It is recommended that the outside dimensions of the aluminum windows be increased and also some black felt of approximately ½ inch width be placed around the edge so that it would fit against the window face, so no light can leak in. The only light on in the cockpit was just a small red light above the GET digital time clock which presented very little light. It would be very black inside until the spacecraft nose would drift around into the sun. At such times the light that would leak in around the edge and increase the ambient light to a condition that would wake us up and call our attention to the fact that we were going into the sun. So the outside diameter of the window shades need to be increased slightly and also a black felt ridge could be put around it so that no outside light can get in during this period of time. I felt that this contributed considerable to us waking up.

Cernan   Anytime the sun shines in or near or around the windows it will seek every crack that there may be.

FCSD REP   Did you hear anything during this period? Noises?

Cernan   I could hear the suit fans on my side.

Stafford   The only ambient noise inside the spacecraft that contributed to this point was the suit fans. I had Gene go on the silent switch. I kept my headset on my left ear but due to the ambient noise of the suit fans I obtained some tissue and made a plug for my right ear to try to cut out the noise. This was partially successful.

Cernan   I had the noise in my right ear and it appeared that the suit fans were right there but the noise did not bother me or keep me from going to sleep. I slept the next two nights very well with the suit fans on. One of them on.

Stafford   Now again this sleep period was not nearly as deep or as restful as the subsequent sleep periods. You can always feel the pressure suit around you and the various points, which is a real big difference from all the other sleep periods you've had in your total life. This I'm sure contributed to it and one thing that can kind of take the edge off it is a couple of APC's or simular type of medication.

Cernan It was a new environment in that you were sleeping in what was something close to zero g and you had to contain your arms. And to contain your arms with cuff rings of the suit was something that was difficult. There was one thing that very definitely bothered me concerning the suit. That was the neck ring. The type of work I was doing was pencil and paper and always working in my lap, I had to have my chin down and my neck and my chin, after the first day, got raw from the neck ring or the pressure of the ring. No, I'm talking about the neck dam, the neck dam itself and the ring. The hard ring in rubbing on the rubber in the neck dam got my chin very raw.

It was mainly because I had to work down in my lap and look down, and the ring was always in the way. This was more than a nuisance, it was uncomfortable at times. This was also somewhat of a problem during sleeping, because you had to secure your head in a position where it would not bob around any and again the neck ring was always in the way.

FCSD REP — This is a little out of place right here, but during this first orbit you had quite a bit keeping you busy there going after the target and so forth, did it give you any trouble at zero g environment and having so much to do at first?

Cernan	Once we were in zero g environment for all practical purposes it was exactly like one g. I felt no strange new sensations, no difference, no change. The only thing you would have to do is just secure pencils and papers and everything else when you weren't holding on to them. The only thing during the first orbit that gave me any problems was the helmet. There again, because of doing paper work, computer work and this type of thing, the helmet was something you wanted to get off as soon as you could.
FCSD REP	Would you elaborate on that just a little?
Cernan	The helmet is big and bulky. You can't turn around. You can't look around. You can't move your head nearly as freely. It's a little bit more uncomfortable than unhelmeted operations. It was my strong desire to get that "Go" from Carnarvon just as soon as possible and get the helmet off because, I think it's a definite work restriction.
Stafford	The next highlight occurred at Kano contact when we completed the sleep period and started the platform alinement. We'd been drifting all

night long. We woke up pointed at the sky with rates about all three axes. We immediately turned on the IGS power supply, the Acme Bias power, went to Pulse mode, and by looking out the window damped the rates to zero right away obtaining a real fast position of 180 degrees yaw and alined the platform 0, 180, 0.

4.7 <u>Third Rendezvous</u>

Cernan

Our Phase Adjust Maneuver followed. At 18:23:19 it was a Delta-V of 2 feet per second, zero yaw and zero pitch, burned in Platform mode using the aft thrusters posigrade. The residuals came out to be 80 zero, 81 minus a tenth and 82 zero.

Stafford

All platform alinements were carried out with considerable ease and each time as time permitted a check was made between the primary and secondary scanners. The alinement between the two scanner systems appeared to be practically zero error. One thing noticeable was the phasing going into sunrise or sunset. The secondary scanners were superior, as previously briefed they should be, to the primary scanners as far as losing lock to the horizon and putting false inputs to the platform or input to the spacecraft when using the Horizon Scan Mode. In the majority, the critical alinements were made using the secondary scanners.

Cernan — The Height Adjust Maneuver came at GET 19:08:16. It was on time and it was 17 feet per second, zero yaw, zero pitch, burned in Platform mode, using the aft thrusters posigrade. Residuals were 80 zero, 81 of plus 0.1, and 82 of minus 0.2.

Stafford — The crew status reports were made over the Canary Islands. At this time we'd like to comment, that because of all the detailed bookkeeping involved, it is our recommendation that we give only the counter total on the water gun and let the huge medical support facilities we have on the ground compute the amount of water in ounces that we have consumed during the period. The oral temperature was not a real nuisance factor at that time.

Cernan — It's worth while to talk about meals. When you have a day such as we had the first day, including the sleep period, say for the first 24 hours when we had the three rendezvous, we did not consume meals individually or at any particular time. We ate when we could, we split meals, we shared packages. We knew we needed and wanted nourishment and we split meals as time permitted. I think this is very important and I don't think it's ever going to change when you're talking about M=1's, M=2's, 3's or 4's, 6 or anything when you're completely involved the way you are. You just don't sit down to dinner like you might somewhere else. This is the way it's going to be and you can never say you fully consumed one meal or another because you may have two or three meals spread out around the spacecraft.

Stafford This is the difference between operational research flight and one that's primarily slanted for bio-medical research where this is your prime existence to endure for a long duration or period of time. When you have lots of programmed activities every day the only way you are going to eat is piecemeal throughout the day. Only if you do have long periods of inactivity where you can program a meal in will you do this.

Cerman — The NSR burn for the rendezvous from above was updated twice, changed by a matter of about a minute. We did not, obviously, burn the first update. We got a further update and burned at 19:54:24 on time. All of our burns ended up to be right on time. We had a Delta V of 14.4 feet per second. This was done with yaw 180, pitch 38 degrees down, and we used our forward firing thrusters, which gave us a posigrade up burn. We zeroed address 80; 81 had plus one tenth and 82 was minus two tenths. We had 32 percent fuel remaining at the end of this Coelliptic Maneuver. The computer appeared to be working fine. There were no problems with initializing the Start Comp mode when we were in Catch-Up. We had no further problems with it after our initial rendezvous.

Stafford — During the first rendezvous was the time that the computer anomaly was observed. After this we had no further anomalies with the computer.

Cerman — We were updated with address 54 for the Closed Loop Rendezvous. It just so happened that I had had that same update prior to lift-off. So, it confirmed the information I had aboard. Do you want to talk about target acquisition, Tom?

Stafford Right. Even though the flashing lights were turned on, I could not see the flashing lights throughout this period of time, which meant either the squib battery voltage was extremely low or they were not on. But throughout the third rendezvous the flashing lights were not seen at all. At one time as we progressed on after the NSR maneuver, we determined from the radar that we had Delta-Delta R, which showed we had ellipticity. We were looking for the target at night time and I could not see it. However, as the moon came out and just before sunrise, I saw a large white blue light starting to glow. I checked this position through my reticle with respect to the radar and saw that this should be in the same position as the target. And just prior to sunrise, BEF, and passing over the Canary Islands, this blue-white light grew in intensity far bigger than any reflected light that I'd seen. The ground was black below it. Just at sunrise, still in reflected moonlight, I would estimate that the reflected moonlight on the ATDA gave a target that was approximately four to five times brighter than Venus. It was the largest reflective light target I've ever seen. I think this was due to the background. This occurred at a range of 20 miles and the source was reflected moonlight. It was the most brilliantly contrasted lighted target I've ever seen. At sunrise as we passed the terminator, the intensity started to decrease. It was then seen in reflective sunlight due to the sun angle. And then as we proceeded, the clouds below became fainter and fainter. The target diameter decreased and became slightly orange in nature. The diameter continued to decrease and completely disappear. From this point on until we were less than three miles from the target in the final terminal phase, I did not see the target.

Cernan — Getting into the rendezvous itself, we started recording data at 4 minutes after NSR. We were at 64.14 miles and we were at 81 feet per second at that time. We pitched down to aline the platform at 90 degrees or 189 basically. We were in aline for approximately 1½ minutes. Address 84, which should have given us a sine of the elevation angle, was very poor information. It bounced from angles that were obviously not true to extremes on the other side which were obviously not true, so we based our alinement pretty much on time. When we went back to boresighting on the target, we got some pretty good angles, ranges and range rates and closed loop solutions with the computer performing as it should without the self-initiated Start Comp cycle. The velocity to initiate and the total velocity for the rendezvous, both came down very slowly. However, about every fourth or fifth solution this number would start to go up. In other words, the numbers should come down in total velocity required. They did, but at every fourth, fifth or sixth point one would come up and be a higher number than a previous one. And then the next one would come back down and be in the proper sequence. This we were aware of but it didn't bother us unless it had happened that it might come at point C as a desired solution. We were computing Delta- Delta which gave us the measure of ellipticity and we concluded that we started NSR at 7 1/2 miles with an ellipticity that put us out to about 8 1/3 and 8 1/4 miles. By the time we initiated we were probably close to 7 miles, so we definitely had an ellipticity which played a vital part in our choice of Terminal Phase Initiation. The ground gave us 16.5 forward, 0.3 of a foot per second up and 2.5 right. Our closed loop solution gave us 19 forward, 4 down, and 2 left. Our backup solution gave us 16.5 forward and 3 up. The closed loop, considering our ellipticity, was obviously wrong in its normal to the line of sight component because it gave us a solution down. We definitely did not want to go down because our ellipticity was in that direction. We wanted to go up, so we decided to go with the backup solution and use 17 forward and 3 up. At point C, our velocity to initiate was 19.1 and our total velocity required was 37 feet per second. We did initiate, then, with the backup solution. We predicted initiation time would be 7:50. We initiated at 7:50 and 10 seconds later, the Start Comp light came on. So we were using purely backup at that time, but the closed loop was computing and we did push Start Comp at point C, obviously, and we were going closed loop, or we were going to take a look at the closed loop corrections. Correcting one previous statement, we computed the Start Comp light should come on at 7 minutes and 50 seconds. It came on at 8 minutes exactly. We initiated the Terminal Phase Initiation at 8 minutes when we saw the Start Comp light come on. Our first backup solution showed us a required velocity fore and aft of zero and a required velocity of 3 down. We were convinced that the closed loop was cranking out information on the basis of reading out address 69 at 4 minutes, and, as a result, we decided to wait and see what it would give us and burn to zero.

Stafford — For the angle tracking, there were no optical means available to us so I had to average out the rates that were being displayed on the radar needles. We'd start out after a lock on, after a switch you could definitely tell when you switched antennas, and you would start down with a very low bias, practically no bias. Then you could see the bias build up, the sinusoid would be superimposed upon the bias and it would switch antennas. You might pick up some bias just to start with but always the sinusoid would build up toward the end prior to breaking lock. Prior to switching antennas, it would very seldom break lock down there.

Cernan In contrast to the first rendezvous where we had visual acquisition and could track visually, where we knew our angles were good, and at least our Delta angles were constant, on this particular rendezvous, we had to base our angle upon radar bore sight. The radar bore sight, as Tom just mentioned, left a little bit to be desired, so we sort of put a little less emphasis on our backup solutions during these corrections or at least biased them in thought as to their accuracy. So, we did not burn our first correction. We did not get a second backup correction because we went down to aline the platform at this time.

Stafford: The platform was designed to give us a zero torquing rate error at 146 nautical mile orbit and we were higher than that. We were up to 168 to 170 nautical mile orbit. After the transfer and 5 minute data gathering period after transfer, I came backup to the 0, 180, 0 position and alined the platform for 5 minutes and then pitched down to pick up the closed data points. So we were able to get the second backup corrections.

Cernan: An interesting point at 7 minutes, we were able to get a range, we never lost radar lock on during the alinement period. We were able to get a range at 7 minutes at 10.21 miles. We did not get a range rate. During the time of this alinement up through 10 minutes, we were not able to get ranges and range rates although we did not lose lock on. The computer did not change its range at all. We expected to get ranges from the simulator although we thought we might lose range rate, because the simulator behaves this way. But we could not even get ranges although the lock on lights stayed on through this whole period. Second correction backup, we had no data of course, because we were alining so we did not get a backup solution. The close loop solution said 4 aft, 1 up, and 5 left. We burned 4 aft, 1 up and 3 left and we decided to go with this solution because it looked reasonable from the data that we had and from our target center coordinant plot. The third correction open or backup solution gave us 2 aft and 2 down. And again the angle data for the up down corrections left a little bit to be desired because we still did not have a good visual lock on at that time. The 4th correction, the backup solution gave us 1 aft, 5 down, and a close loop gave us 2 forward and 10 down and 7 right. Well, we saw a line of sight of error developing so we burned the closed loop solution. However, it appeared shortly after, that this 10 down was too much to burn because we had line of sight corrections that required us to burn up. So, possibly the 5 down would have been a better number to burn. But we went ahead with the closed loop and burned 2 forward, 10 down and 7 right. Here it might be noted that the second correction that the close loop gave us was 5 left 4 out of plane, that is closed loop correction, and the second close loop correction gave us 5, we burned 3 left. The second closed loop correction gave us 7 right, and we were forced to burn 7 right at that time because it was pretty obvious, I guess, that we needed it.

Stafford — We showed that the close loop solution was in error for the out of plane component there on the first mid-course correction.

Cernan — We utilized the same braking technique theory during addresses 25, 26, and 27 after the fourth correction and went to the line of sight control on the ball. Line of sight control as we practiced in the simulator was no problem. We had no star background. We had the target moving very rapidly over the earth's surface. By utilizing the 8-ball and reading address 96, we were able to tell exactly what our line of sight was and we then got it under control. Using, as I said, the same braking techniques of braking periodically in Catch-Up Mode.

Stafford — Throughout the Terminal Phase Initiation and until we reached a range of approximately 3 miles or less, we were not able to see the target, even though we were pointed down at the target and should have had some optimum lighting conditions. At this time, we were going across the land mass of Sahara and some of the tropical rain forest, so we had an intermittent type of background feature. The reflected sunlight from the ground was so brilliant, particularly over the desert. With a full maximum scale on the optimum side, I could not see the reticle pattern. It was also impossible to see the target. Also the motion of the earth below was pretty phenomenal. You realized that you were moving at a good 25,700 feet per second. The target finally came into view at approximately 3 miles as a small black dot. It was intermittently lost as you would cross various terrain features.

You could see various out-croppings of igneous rock in a desert where you would completely lose it. Then you would cross into basic sandstone formations at which time you would see it. After we crossed over the Indian Ocean, we could see the white body of the ATDA. At this time it was very difficult. I was checking angles on the ball maintaining radar locks and trying to check the optics. I thought this was very important for braking. I would say that being able to perform a rendezvous from above under the lighting conditions that we had, without radar would be impossible. At the final line of sight, I could see the features grow within the last mile and come into focus because of the contrast between the blue ocean and the white body. At this time, the range rate needles on the analog gage as previously described had been going full scale then back to or near the proper range. Just fluctuating back down, and we reduced the velocity at approximately 1 mile to about 12 to 15 feet per second. We continued on at a very comfortable rate and at

2000 feet we reduced it to about 7 to 10 feet per second.

Cernan — At 1.3 miles, we had 24 feet per second, at 1.14 miles, we had 20 feet per second. We started braking at .93 miles.

Stafford — At approximately 2000 feet we reduced it to around 7 feet per second, closing right along the line of sight. I was concentrating on the target and just made a cross check to range rate meter. I made a mistake and reduced the line of sight to a negative value. In other words, I saw it growing and I pulled it off. The range rate needle was fluctuating back and forth and I thought that I was down to 2 or 3 feet per second. It actually was negative and right away the total pitch angle changed. I realized what had happenccd and then I hit the Start Comp on the computer and added about 8 feet per second to insure that I would close on it. This was the only mistake that was made in that rendezvous as far as the correct maneuvers in the rendezvous. And this probably cost us an estimated 10 to 15 pounds of fuel.

Cernan We completed this rendezvous after that and we were again within about 60 feet or less station keeping. We had 18 percent fuel at that time. I'd like to make a comment here, because I think that it's probably appropriate here about these residuals. I said we had no probelm in nulling the residuals and we didn't. They were all within limits and I think without any problems we could have gotten them down to zero, if we had so desired. All this is true, but there is one thing that we did do that may be a little bit different then has been done in previous flights, we punched up the residuals twice. We made the residual burn, we blipped the thrusters, and then I'd punch it up and it may say minus 0.5 of a foot per second and then another couple seconds later I'd punch it again after we had time to settle down in terms of any residual thrust, and it would end up to be maybe zero, or minus 0.1. So, this may be an explanation of the residual problem that Gemini VIII had. Either we ought to wait about 10 seconds or 5 seconds after we thrust out residuals to make sure that everything is nulled out and then push 80, 81, and 82, or else push them out a couple of times to see whether they change without doing any thrusting in between the times that you are actually pushing out 80, 81, and 82. We did this on all of our - we noticed this very early, I guess, on about the first burn. I pushed it out and then I'd push it out again and I saw two different answers and then we did this on all of our burns. We'd push all our residuals out twice.

Stafford On the Tananarive pass the eat period was performed shortly thereafter, which was a very time consuming job for both the crew members to prepare the food and also station keep at the same time. We were also starting to become very fatigued having completed three rendezvous within 21 hours in one day. At this time, both of us talked over the situation with respect to our physical condition, and also the fact that we had requested permission to tap the shroud on the ATDA with our docking bar and this permission was refused. We reasoned from a material standpoint and also a logical standpoint that we could not use the Gemini which is stressed for plus or minus 30 g's and the docking bar which has a 2000 pound stress on it to touch the ATDA. It would seem rather illogical to have a Pilot in pressurized 3.5 psi suit to perform the task of starting to investigate the ATDA. Also we questioned the ground. Did they have a useful purpose for EVA at this time with respect to the ATDA and what was their planned sequence? It appeared to us that the ground did not have a very detailed or precise plan for which to approach the problem. It was then that we made the recommendation that EVA be postponed until the third day and that we be in a rest period after that time. Also associated with that was the tumbling rates, the ATDA and the question whether the stabilization control system could perform the task of giving us a completely stabilized bird. We also knew that with the precise control system of the Gemini we could fly a position anyplace up to the ATDA, and we also knew that it was an unknown in EVA, as to what position we could make with the astronaut in an EVA condition.

Cernan — In retrospect knowing what we know after the EVA and the rates that the EVA Pilot imparted to the spacecraft, our plan, in any event was to work with the ATDA with the RCS systems both off. It appears to me that any EVA work on an unstabilized ATDA would have put quite tremendous rates onto it through the movement of the EVA Pilot, which we evidenced on the spacecraft during the EVA on the third day. This really would have meant that either the tether or the umbilical, or a number of things, would have probably got pretty tangled up at that point with the ATDA. The other thing we questioned in our own minds, when we saw the rigidizing and unrigidizing sequence take place, is whether or not the two coil spring cylinders that actually pull the halves of the ATDA apart were fully extended. So that if that line were cut, or if that band or the electrical line holding that shroud together were cut, whether this thing would drift apart or whether it would spring apart. We really weren't sure at that time whether those cylinders were fully extended. With that in mind, and with ground concurrence, and with our 21 hour day that we just had, we decided to slip the EVA to the third day.

Stafford The next item concerns the continued Station Keeping with the ATDA and the evaluation of the command sent to it over the United States during the pass. The RCS rings were turned on over the Texas site and immediately we observed the thrusters to fire and go into a duty cycle which we'd estimate of at least 60 on and 40 off or probably more like 70 on and 30 off. In either Low or High mode the thrusters fired nearly

	continually. We were so close to it that some of the N_2O_4 droplets from the RCS plumes came over and impinged on the spacecraft. You could very definitely see these yellow drops coming out from the RCS plumes and impinging on the spacecraft.
FCSD REP	You were at 60 feet Tom?
Stafford	No, we were anywhere from 60 feet to 65 feet at this time.
FCSD REP	Were the thrusters firing on the.....
Stafford	Well 12 feet, 10 feet.... we had worked around to various angles. The closest point of approach, I'd say we were within 10 feet at this time, then we moved out.
Cernan	Closest point of approach at this time was maybe 10 feet.
Stafford	10 feet, yes. Later on it was about 1 foot or less up on the shroud so we could roll right over and take a picture of the wires. Take a picture of the goof! This was very easy to do. It was rotating along about the X axis and we could see the dipole antenna. We kept clear of the dipole antenna, rolled the Gemini on its side and rolled right up to where the X axis of

the Gemini was 90 degrees to the X axis of the ATDA, and rolled right into it, and snapped the pictures. Making sure the alligator wouldn't bite us that way.

Cernan: I think the ATDA inspection is more vivid with the pictures because we took many 16 mm and 70 mm pictures and I'm sure they can explain a lot more about it then we can.

Stafford: It was obvious to us at that time that - actually the first time we saw it the exact cause of the problem. I think its been borne out that our analysis in the air pinpointed the problem exactly, and that we both said that either the lanyards had not been installed on the electrical connectors or else the lanyards were installed but were not hooked up. Even from 2 feet away its real hard to ascertain exactly where that clip was. We could definitely pinpoint the problem. The docking cone cycling, fully rigidizing and unrigidizing, produced a motion; and the shroud pitched at approximately 15 degrees. Also it appeared that the jaws opened and you could see the jaws open and close, when it was unrigidized and we'd come back to rigidize.

So this proved that the point that Gene brought up that undoubtedly there was still spring tension on those coiled cylinders. Numerous 16 mm and 70 mm pictures were taken at this time, and after decision was made to abandon the ATDA for the rest of the mission, we made a 3 feet per second retrograde burn and continued on the rest of that day with a rest period and experiments.

4.8 D-14

Stafford

At 27 hours over the Hawaii pass we picked up the first D-14. Throughout our training experience on this it became evident that a more logical position for the D-14 experiment should have been selected. The D-14 experiment, because of its antenna position in the Retro Adapter, required that we yaw left or right 90 degrees and then roll right to a nearly inverted position of 158 degrees. It would have been every bit as easy to put the antenna out the other side of the Retro Adapter, where all you'd have to do is just roll 12 degrees; and also they could orientate the whole box where we'd just be at zero position and pitch down to the horizon. In this case it would require very little fuel to perform the total experiment and also we could have done it without the power. However, we had plenty of electrical power and we did all the D-14 experiments with the Platform ON and the Computer ON to give us the pointing accuracy. We put a precise load in the computer and flew the maneuver nulling the IVI's.

Cernan D-14 at 27 hours and a D-14 at 27:16 and a D-14 at 28:28 were all on time. The antenna was extended prior to the first D-14 and left extended. By on time, I mean that we activated the transmitter at the designated time and held it ON for 12 minutes and the attitudes were held very well throughout all the D-14's. I don't think there was any other than the attitude constraint of the antenna. There was no major problem in actually maintaining the attitude once you got there.

Stafford The technique that was worked out by the Flight Crew Support Division proved out very well and it was very easy to follow the pointing commands with respect to the IVI's. It appeared from our onboard analysis that we were able to give a precise attitude throughout the entire time of transmission for the experiment. All the experiments were carried out on time, to the second, with respect to transmitter ON and OFF.

Cernan

28:43 under systems checks - all the systems looked good at that time with the exception that we noticed a H_2 transducer malfunction. Prior to any Cyro readouts we just periodically checked them and the Command Pilot picked up the failure in our gage and it was verified that the ground also had a failure. They concluded there was no major problem, that we had hydrogen and they gave us hydrogen quantities from that time on based upon temperature and pressure. Our computer functioned normally from the end of the first rendezvous throughout the whole flight. Never had any problems with it at all. At 29 hours we received PLA updates which were no problem to copy. One thing may be worthwhile mentioning here is reading up numbers. Five is read five and not fiver, and nine is generally read niner. The issue I'm making right here is that five is never fiver, its always five and this at times led to confusion until you realized that - until you compared a nine with a five coming from the same person.

4.9 <u>S-11 Experiment</u>

Cernan

We had an S-11 at 29:16 and subsequent S-11's thereafter. We went through sequences 01 and 03 on three succeeding night passes, and we completed them all. We completed what we felt were within the limits of the camera bracket. The Pilot's ability to get into position to utilize the site, the sighting capabilities or restrictions and the capabilities to hold the spacecraft within required pitch, roll, and yaw limits. All of which leave a great deal to be desired. That is why we both are interested to see what kind of results we got on S-11. I might add that it was a two man operation throughout. One of the major problems other than some of the equipment problems which we noted prior to flight such as the sight, were the fact that in a simulator the camera bracket is mounted such that you have to get in a lower left hand corner of the Pilot's seat. In the simulator in one g this is difficult but it can be done. But in zero g flight it's extremely difficult to hold yourself, not to get down in that left hand corner of the Pilot's seat, but to maintain that position and maintain it rigidly enough so that you can hold onto the camera, press the shutter and have the Pilot time it; and also control the pitch with the bracket. All these things add up to a very tough attitude control problem. Not being able to stay in position is certainly not the least of these problems. We could not fire thrusters during experiments so the Command Pilot, in combination with the Pilot, verbally and manually, flew the attitude controller at times; had to get to the proper attitude and then maintain the rates. Generally the experiment was a great deal of difficulty in attempting to achieve the requirements of pitch, roll, and yaw rates that were desired.

Stafford — The position with respect to the Attitude Indicator, when the camera was alined with the horizon, was a pitch down of over 30 degrees and a roll right of 20 degrees. The total experiment could have been made so simple if the bracket on the right had been boresighted with the optical reticle on the left. We could have given within a tenth to a fifth of a degree in pointing accuracy, and pitch right on the horizon. The Command Pilot could have pointed with the reticle and then the Pilot taken over for the fine alinement - then the Command Pilot damps rates. It could have been done nearly instantaneously. This way a lot of fuel was expended and I was not sure whether we were exactly in line with the horizon.

Cernan We were not in line when I got extremely close to the horizon and we had our rates nulled. It was such that you had to take advantage of that position and take your exposures. Because you might spend the next ten minutes trying to get exactly level with the horizon. Level being a questionable term anyway because the site was concave upward and the horizon is concave downward. Besides we were not able to acquire the exact position on the horizon, that you want in the reticle; if the camera were boresighted on the spacecraft. The important thing is if we were slightly off in pitch and we would pitch down due to the position of the boresight of the camera, this would also induce roll - coupling roll. So we now would have two axes to contend with. So you had to continually cross couple between the pitch and roll to get your desired position and your desired null rates.

Stafford: It also worked a large work load on the Pilot to maintain this position, and I can tell that his respiration and pulse rate were increased considerably by the way he had to force himself down in his seat, turn his head over to the side, and hold this position. It is our recommendation that this experiment not be flown on another Gemini mission until the hard work can be modified to where the camera is alined with the optical sight.

Cernan: One additional point, is the exposure timer failed a number of times prior to flight, so we discarded it as part of the equipment. It was either taking the experiment without this exposure timer or not taking it at all. So to get something out of it, we recommended going ahead and taking it and we would time manually. Timing manually is no problem because the exposure timer was not correct. When it worked it was within plus or minus 3 or 4 or 5 seconds anyway. Timing was not a problem. The problem did occur because the Pilot had to, in holding the shutter down, also had to exert some force on the camera. This was because he was using that hand not only to hold the shutter down but he was using that hand to maintain his position down in the seat. Well, when you exert some force on the camera it in turn puts a slight rate into the camera which was very difficult to damp out. So I had three inputs. There were Spacecraft rates into the camera, there were the Bracket Pitch rates that could be put into the camera and that were used, and there were the perturbations that were put in by my tendancy to either float or reposition myself. I would inadvertently, although I realize that with the possibility I tried not to,but inadvertently I sometimes tended to actually put some pressure on the camera and change its pitch position or its yaw position slightly. As I say we are very much interested to see what kind of results we did get because we spent a great deal of time, a great deal of effort hoping that we would get something out of this experiment.

Stafford

The basic reference for the East, North, West, and South horizon was made with respect for the platform. The platform was powered up continually through this period of time. Since we alternated between the S-11 and D-14 experiments, in between times we would aline the Platform so we had a very accurate alinement and pointing command.

Cernan

That takes care of the camera alinement because the camera alinement was based upon picking East, North, South, and West from the Platform, and biasing it such that we could get a camera boresight on the respective horizon. We did take the sunrise pictures Sequence 03 with the filter. We also took part of 01 where we actually fired the thrusters during one of our yaw periods, over to the sunrise, which was requested as part of the experiment. We took everything we could - everything that was required with S-11 with the exception of the very last update on the last night. The reason we did not take this picture was because all that gear had been restowed and just about in an inaccessible position prior to EVA PREP and we felt that since we had to get it out and restow it again for retrofire for the next morning that to get to it would have been much more effort than two pictures would have been worth. There were only two exposures desired. It was an equipment accessibility problem at that time. Had we not had gone through EVA preparation and EVA restowage we might have been able to get back at the gear. It was just not a practical thing to do for that last update on the last night. Other than that, that's the only experiment update that we did not do. We saw no unusual phenomenon.

Stafford — We did observe a couple of meteors burning in the -

Cernan — Yes, that's right, we did but you can't pick up a camera fast enough to take a picture when you see these.

Stafford — It's all over in a matter of 1 second or 2 seconds. They were below us in altitude and crossing approximately 30 degrees to our flight path axis and decreasing trajectory. The color was a whitish-yellow with a slight trail.

Stafford — One never knows when one might see a meteor.

Stafford — After the EVA was terminated due to the fogging problem it was also evident to us that the S-1 as originally planned was somewhat misconceived by the experimenter and other people in respect to having a flight crew member stand in the seat and holding the S-1 camera in a stabilized position. From our experiences in EVA we found that even the slightest motion of the crew member - that is in the Extravehicular Mode would torque the spacecraft to rather large rates. So, therefore it would have been impossible for the individual to hold this. Also the tendency to float up - it would have been nearly impossible to stand in the seat to perform this experiment. The experiment was performed during one complete night sequence after the ingress from EVA and the crew had completed the restowage.

Cernan

S-1 experiment was updated for a time of 54 - I believe it's 54:37 or 54:57 GET. It was updated to take pictures from within the spacecraft of the Milky Way and of the North, West, South and East horizon. Two exposures each. The S-1 has 18 exposures all of which are 30 seconds each. The Pilot inadvertently exposed or ruined - I assume that the first exposure was ruined - so all total we took 19 exposures. I feel that the first one was ruined and the last one - there was no film left. We did take every exposure that was available to us. We started out with the Northern horizon and the reason that we started out there was because of the moon which may play a great effect in all these pictures. We had all the cabin lights off with the exception of the GET elapse time red light and the Attitude Indicator red lights. Everything else was off at that time. The camera was held flush and firmly against the window, and it was sort of manually bore-sighted somewhat like S-11. The Pilot told the Command Pilot to control the spacecraft

[redacted]

to a pitch and roll attitude that would put the camera generally boresighted on that particular horizon and then nulled the rates. And we took two, 30 second exposures and we did this from North, to West, to South, to East. Then we started up the Milky Way and took approximately four exposures from the horizon, in...the camera was held vertically in plane with the Milky Way and we took four exposures from the horizon on up to almost our zenith at which time the brightness of the moon was evident and even that last exposure up there was probably over exposed because of the moon. And we had to quit at that point. We probably had about two or three exposures left so we took a couple more of the Eastern horizon. The last two exposures were taken of the Eastern horizon, just as first morning light was coming over, because we felt that since we had the film, we'd make use of it. There was no thrusting during the 30 seconds exposure time. There was some thrusting between exposures and certainly thrusting change from horizon to

[redacted]

horizon. Our feeling is, that as mentioned earlier, that to get anything out of this, on this flight; looking in retrospect at the EVA, that this was the way to get the most out of this experiment. The hand-held 30 second EVA mode of operation of this camera...I feel would have given us no results at all because of the inability to hold anything for 30 seconds in the EVA environment.

Stafford One system anomaly was noted at approximately 44 hours and 30 minutes in that the amount of water ejected from the water gun was greatly reduced. It was then determined that the lever mechanism that actuated the charge and expulsion cycle would not completely finish the stroke to the full up position. Associated with this was the fact that the counter would not click to the next digit. The estimation of the amount of water that was obtained per shot was approximately one quarter of what you would get in a normal shot. At first we throught that there was a possibility of a mal sequence from the water flow from the adapter into the cabin; however we found that by exerting great force on the bottom of the lever, we could force it up and by waiting a long period of time, we could obtain a full charge of water in the gun. After a sequence approximately 50 to 60 cycles this disappeared. Then right before reentry when the crew was taking in a large amount of water for the reentry sequence, we determined that we had the same problem again. However, the amount of effort that it required to get to the top position was less, but the amount of water dribbled to practically nothing out of the gun. So, it should be investigated as to whether we had reached the end of the pressurization cycle from the adapter into the cabin area or whether it was a malfunction internal to the water gun itself.

Cernan — You might mention that we did dump a lot of water through there.

Stafford — We dumped a lot of water through the urine device.

4.10 EVA Preparation

We had the cryo readouts at Carnarvon, checked propellant quantity and started the unstowage. In this we followed the check list that we had trained on for the past 3 months. We found that the checklist was invaluable as far as each individual item and also the associated action of each item. This was the first time we really incorporated the GFAE, its location in the spacecraft at each chronological period sequentially and also the action that goes with this. With this we had a fairly clean cockpit and were able to progress sequence to sequence with the minimum of effort.

Cernan

The important thing about this check off list; every piece of gear that we unstowed from what was its permanent place was unstowed and put in either an interim place prior to hatch opening or put in its final place for hatch opening, depending upon how the unstowage sequence went, but every piece of gear that we unstowed had a place for it, whether interim or then permanent. We just didn't have pieces of gear that we didn't know what to do with, which is the most important thing of an orderly EVA prep. We worked on this and I'm really very happy that it went very smoothly and very clean.

Stafford — The stowage that we had worked out for the left hand aft box which contained all the auxiliary EVA components, worked out very smooth. The major item to unstow from there was part of the spacecraft umbilical and this item came out very well.

Cernan — The majority of the EVA gear was stowed in the Command Pilot's aft food box. I think it is very important that it be stowed there if at all possible in the future flights because it allows the Pilot to do the least amount of work during EVA prep or during the first part of EVA preparations. This to me was very important. Unstowing that aft box is not an easy task. The Pilot's box was unstowed (cameras and so forth) for pre-rendezvous so he did not have to go in his box during EVA prep at all. It is very advantageous to have the Command Pilot do the unstowing and the Pilot, can do the connection from the standpoint of fatigue, as well as having a more orderly progession of events. Handling of the ELSS, I found, went very well. As a matter of fact this is one thing in the zero g environment that went so much better than even the lightweight training packs. It wasn't always getting involved and tangled in things; it was no problem at all, I don't believe.

Stafford — That's right, everything went real smooth. Again this is to be contributed to the many times in training exercises that we had gone through and we knew each item by heart and also we had the check off list which had been incorporated over a long period of time.

Cernan — The 16 millimeter camera: we had the Pilot's 16 millimeter camera put above the Pilot's seat prior to Egress for ease in him getting it and putting it in the bracket on the adapter. This worked out very well. We had little Velcro tabs on the circuit breaker cord from the right hand Aux Receptical and these were just tabbed over the rear top side of the Pilot's seat to keep them out of the way during the EVA, during the stand in the seat, and during Ingress. This all worked out very fine, just as planned. In addition to the 16 millimeter camera on top of the Pilot's seat, we put the EV Hasselbald that the Pilot was going to carry on the ELSS and we put the S-1 camera up there, either up on top of the seat or on top of the camera box which had Velcro on it and they all stayed there, were easily accessible and that part worked beautifully. It wasn't a case of having to reach back in the cockpit which would have been a large problem. Installation of the hatch closing devices went just as we had done before. No problems. Donning the helmet, the visor, and the gloves and the wrist mirror, went as expected and there were no problems. The single EV visors we have, I think, are far superior to the double visor that we used to carry and it is easy to install. It swings very freely in 1 g, either up or down, but in zero g it holds in place real well, whatever position you desire. During the EVA prep the Pilot, somewhere in the process, knocked off the scanner heater circuit breaker; this showed up preliminarily as a control malfunction which Tom will to into.

Stafford — We alined the platform during the eat period prior to EVA prep and this time we used Pulse mode and alined the platform and had a very accurate alinement. (Not that this was really required for EVA, but we were in good alinement.) We went then to ORB Rate and PLAT mode. This was in the middle of the sequence of going through the checklist when suddenly, we heard a thruster fire or a series of thrusters fire, I noticed that we started a rapid roll to the right which I would ascertain built up to about 20 degrees per second. I immediately hit the control mode switch to DIRECT and could tell that the acceleration had stopped and then put in left roll and stopped the spacecraft in about a 90 degree position. I then made several more blips and brought it back into the general ball park, checked PULSE Mode and got it back to the 0, 0, 0 position.

[redacted]

I immediately checked RATE COMMAND and REENTRY RATE COMMAND; these all worked good which showed that it was not a malfunctioning gyro. I then went back to PLAT mode for a second and got the same thing, and came right back to DIRECT, so we determined that the malfunction input occurred during PLAT mode. At that time I went back to aline and we also noticed that the needles were non-directional when we were 0, 0, 0 with respect to pitch and roll, however yaw was directional. And none of us had ever seen this type of a malfunction before in the simulators , or failure modes that had been given to us. Immediately we started through a complete sequence check, too. We switched to secondary ACME BIAS power, secondary logic with respect to the yaw, pitch, and roll, and changed everything over to the secondary system and went through another check in this same system. Therefore, we knew that the malfunction was common to both primary and secondary units of the total control system. We continued on, we informed the ground

[redacted]

exactly our indications, continuing to hold at 0, 0, 0 and PULSE mode, when we came over Carnarvon and they told us to check our scanner heater circuit breaker, which we did and immediately I noticed that the needles became directional. With that I went to FLAT Mode right away, checked it out, and it was good. We then reconfigured the control mode system to be in primary for the ACME logic, the ACME BIAS power, and the Attitude drivers.

Cernan — We did check out number three and number four thrusters. We figured that the problem was in one of these thrusters. As a matter of fact, we figured that it was number three thruster that was out. It appeared very much to us when we turned three and four on, one at a time, and activated the control system that three in fact, was really out, because we could feel, we could hear, and we could see the attitude changes when number four fired but we could not when number three fired.

Stafford — At this time we would yaw right, and we noticed that the yaw right rate was about half that of the yaw left rate and associated with this was a left roll. After the correction of the circuit breaker problem, we continued with the EVA preparation, the ELSS checkout occurred...

Cernan Yes, the ELSS checked out real well. The relief that we heard operating, was not the ELSS relief valve. We soon discovered that it was the spacecraft pressure relief valve. We had the ELSS on, in medium flow with the water boiler off so that the Pilot could keep cool during this period, or at least have some flow, which was the checkout procedure prior to launch. It was okay, but we were not aware right away that the cabin was venting 5.8 PSI and that was the noise that we heard. It was very similar to the ELSS relief valve operation that we heard up at McDonnell during the chamber test.

Stafford In fact, we could not ascertain any difference between the noise and the frequency in which it was occurring and we thought certainly we had a malfunction in the ELSS. Finally Gene got real close to the problem on the ELSS and realized that it wasn't the ELSS relief valve, it was the cabin pressure.

Cernan — It was very annoying because everytime it relieved my ears popped. You had your helmet on during this time.

Stafford — I had my helmet on.

Cernan — I didn't use the spacecraft mirrors at all during EVA prep.

Stafford — I didn't either. The event time hack was given and it worked out extremely well. In fact we planned the total EVA mission with respect to a phase elapsed time that started at zero for sunrise. With this, I had the spacecraft event timer counting up to zero, which will occur at 59:59, and then go to zero exactly at sunrise. Everything from there would bein a phase elasped time referenced to the first sunrise.

Cernan — I put my watch above my cuff gage so that I could get the EVA mirror down around my cuff gage. I set my watch; it didn't make any difference as to what hour it was, 45 minutes prior to EVA at 15 minutes past the hour so that at sunrise my watch would be straight up.

From there I had a minute hand which gave me elapsed time which worked out very well. I had an idea, without asking Tom, about how far we were during the EVA and how much daylight or night time we had left.

Stafford The system integrity check went right on time. We worked out the total operation in such a manner that we ended up ahead of schedule in spite of the control system malfunction. We were ahead approximately 35 to 40 minutes, and we both decided that we would take a rest and just relax before the EVA operation.

Cernan About 40 minutes before sunrise, the only things left to do were donning of the ELSS by the Pilot, checking out the emergency ELSS supply and turning the battery on, turning the water boiler on. We didn't want to do this early, so at that point, we stopped and rested for approximately 20 minutes, the 20 minutes before sunrise. We knew that it wouldn't really take that long and we managed to get through this entire procedure and were ready for hatch opening 10 minutes before sunset. We had activated the water boiler at that time

4.11 Extravehicular Activity

Cernan

and everything was "go" so, we decided to go ahead and open the hatch. We opened the hatch 10 minutes before sunrise. It was completely dark when the Pilot was standing on the hatch. There were no first indications of sunrise at this time. There was no problem opening the hatch, getting out in the darkness, no disorientation, no feeling of being lost in dark space or anything else. It was perfectly normal and the operation went exactly as we planned it.

Summing up the EVA prep, we had 4 hours for the prep, we actually took some of this time to eat. We took some of this time to check out the control malfunction that occurred for a short period of time. We still had about 40 minutes left over. We are both glad, however, that we had the full 4 hours because we didn't know what problems that we might run into..

I contribute the smoothness of operation of the EVA prep to the way the check lists were written and the work that was put into these by our support team prior to our ever beginning to practice. We went over this, pressurized in the mock up many times, working out as many bugs as we could. It sure proved to be a very worth while training exercise.

Stafford — While we were checking the spacecraft hatch opening and closing on the pad we decided that we wanted a good indication when we had a positive lock on the hatch. So, we had small tab indications placed on the forward sill of the hatch. So that this way the individual on the opposite of the spacecraft could look over there and see exactly when the rotating dog went over the center to the full latched position. This gave us a very good check. When we opened the hatch to see when it was unlatched in the proper sequence from the prescribed point, and when we closed the hatch, we could tell exactly when it went over the center and into the lock position. When opening the hatch, as Gene cranked, I could see the dog move right in the prescribed manner. We had vented the cabin. The cabin pressure came right down to 3 PSI. We took it down in real slow steps, thereafter to 0.75 psi to 0.5 psi, then it hung at

0.25 psi for approximately 10 seconds, worked on down to .12 psi and then we could tell that there was still a little positive pressure in it and finally it disappeared. I was hanging on the the hatch closing device when Gene opened the hatch and there was absolutely no popping of the hatch at all.

Cernan — Repositioning the gage selectors was no problem. As the hatch was pushed open a little bit, I repositioned the gage selectors to the lock position, and when we got the hatch fully open, I again verified them, not by sight but by feel, that they both were in a locked position. Standing in the seat was no problem. It was a little bit easier than one g, but when you stand in the seat, you have to make sure that you don't stand right on out of the seat, because it is very easy to make that first step or to pull yourself up so you are standing in the seat and you keep going right on out through the hatch, so you have to make sure that you are secure in some area. Generally what I tried to do was to lock one foot under the orbital utility pouch or under the dashboard basically, to keep myself down in the seat. Many times, Tom actually had to either hold me down or pull me back down in the seat, when I was reaching up for things, as installing cameras and this sort of thing, because the tendency very early and throughout the whole EVA mission was to continue floating on up and this starts right when you are standing in the hatch. When I got up we just waited a few minutes because it was dark and I just looked around and I could see that the lights from within the spacecraft lit things up around my hatch area and very shortly thereafter, it became daylight, the sun came up. The first thing I did was get my visor down and I turned around because I was very interested in knowing whether the handrail on the equipment adapter had deployed. I saw that it had deployed, and I mentioned this to Tom. I then reached back and with little or no effort punched out the handrail on the retro adapter and it came right on out. I may have done this just before sunrise, I'm not sure. I believe it was actually right before sunrise that I did this because I obviously could see it. There was enough reflected light from within the spacecraft to see that and as soon as I stood up and got acclimated, I did punch this out. The next thing I did was S-12, but this was a point for which I think I waited for sunrise because I wanted to make sure that there were no problems and I didn't want to lose the experiment but I took off the restraining cover from S-12. We had activated it on two nights. (The first night and a second night and then locked it on the second morning.) Retrieval of the S-12 as no problem other than the fairing, that you pull out and discard, did get hung up momentarily but with a little bit of juggling, I managed to get it off. I gave it a slight retrograde motion and anything that is discarded during EVA is extremely easy to give motion to...a flick of the finger and it looks to me like it moves out at a foot or two per second. It really moved out and gave us no problem again. I did not have a lanyard for S-12; I determined preflight that we would not need one. I had no problem grasping the handhold on S-12, no problems with my gloves hanging up. I just pulled that thing back slowly, pulled up and out it came. I handed it down to Tom and he put it in his footwell.

Stafford I grasped the S-12 device and placed it between my legs down forward of the footwell. However, throughout the remainder of the mission the device tried to float up. I'd take my hand and try to knock it back down there. One time I finally had it worked around where I had it wedged between my leg and the inner side wall of the spacecraft. By holding pressure over it and reworking the pressure suit around I could maintain enough force between by pressure suit and the inner side wall of the spacecraft to hold S-12 in that position. At this time, Gene was turning around, I noticed that he started floating up. I reached over with my right hand and grabbed hold of one of his boots. I was able to hold him in there within certain bounds in the right seat, by holding on to his boot or by grabbing on to the flat Chromel material that hung down on the back on his heel.

Cernan After retrieving the S-12 experiment, the next thing was to install the EV camera. The bracket went into the hole in the Retro Adapter with some difficulty. You cannot reach the position that is required to put the camera bracket in the hole without actually leaving the seat or at least standing on the handrails. I am not tall enough and do not have the reach to get back there without floating up somewhat in the seat. I was trying to think of how I could restrain my legs, I didn't want to try and spread them apart too far because I had circuit breaker panels and control systems in all directions. As a matter of fact, post EVA, we found that we did knock off a few circuit breakers. That was one of the main reasons why I wanted Tom to restrain my legs.

I took the EVA camera with one hand and put it in the hole with no problem. I couldn't get the bracket to go all the way down and lock in. I ended up going further up in the seat and took my right hand and gave it a bash with my fist, which forced it down in the hole.

So, I just reached over and banged it with my right hand while holding the clip with my left hand.

The camera setting had been set prior to installation. I picked up the EVA Hasselbald, hooked it to the ELSS with the lanyard and velcroed it to the chest pack just as we planned and practiced during all our EVA walk throughs. It stayed there very fine and we had no problems with it throughout the whole EVA mission.

The ELSS tended to ride even higher on me than during the EVA walk throughs, during which I carried it high. One time when I was standing in the seat I took one strap completely off, pushed the ELSS down and restrapped it while I was standing in the seat to get it lower. But it still tended to ride up on me. My visor locking device actually bound on the guard that covers the test right dim switch under the ELSS. When I would turn my head to the right I would have to push the ELSS out of the way to get by this guard so I could continue my turn. The ELSS would ride up again and I'd bind on that guard coming the other way. If that guard were not there I'm sure I would have broken that switch off. There is no doubt in my mind that I would have swung around hard enough to break that switch off. It was somewhat of a pain in the neck. At daylight we had a beautiful view of much of Baja California. There was no lost-in-space feeling, no vertigo, no disorientation of any sort at this point. We checked the suit temperature and pressure regularly. I think Tom called up for pressure checks at times and I gave it to him at times. I told him that my pressure was still holding at 3.9; it held steady as a rock. As long as I could see it, I never saw it change from 3.9, which is, again, what I had expected and was a very good feeling to have because I'd flown with this ELSS in the chamber and I knew what the pressure fluctuations were and the medium, the high, the bypass, and the emergency flow conditions and felt that the ELSS was performing as it should.

Stafford During this period of time, I occasionally asked Gene to just recheck how the suit temperature conditions were, and the suit pressure, and he came back all the time that everything was satisfactory.

Cernan — I was on medium flow all the time, and I remained on medium flow.

Stafford — During this period of time after the camera was set up we had a slight rest period and Gene was standing up, leaning back against the hatch and this is when we had the good view of Los Angeles. Gene was in the seat looking to the North as we were going East.

Cernan — It was very plain to see. We could see the San Clementi and Santa Catalina and St. Nicholas Islands and could very easily see the Edwards Desert. What was the tail number of that airplane?

Stafford — I think it was 451....

Cernan — The umbilical feed up.

Stafford — All right, the umbilical feed out went very smooth. I kept the umbilical bag in my lap and then near the end, I let it drift out and Gene requested that I keep it in there. I slipped the umbilical bag down on the umbilical and kept it in the spacecraft throughout the mission.

Cernan — The umbilicel bag was probably out 3 or 4 feet down the umbilical from the hatch area and I just wanted to keep it down as close to the hatch as we could so that it wouldn't be an added bag floating around out there. Also it would possibly be chaffing when the hatch was closed. But it might be noteworthy (although it did not impress me too much then) that when you fed that umbilical it went out and straight on up through the hatch and I never pulled it out, touched it, or did anything with it.

Stafford — I could notice this from inside the spacecraft.

Cernan — It never got tangled anywhere.

Stafford — It just went out smoothly, went straight up.

Cernan — Straight up the hatch.

Stafford — During this time the spacecraft was in the 0, 0, 0 position using the PLAT mode. Also at this time, I noticed that any time that Gene would lean in the seat, it would torque the spacecraft far in excess of what we had anticipated and the thrusters would make a rapid series of firing to correct the spacecraft back to the 0, 0, 0 attitude.

Cernan

Anytime that Tom was firing the thrusters or that we were in PLAT mode, and the automatic mode was firing the thrusters and I was holding the spacecraft either handrail or hatch, I could feel the thrusters firing. (I could feel them "pow", "pow", "pow".) But anytime that I was on the umbilical or away from something solid, I could neither feel nor hear obviously. The first thing we did was when Tom handed me the EV mirror, the docking bar mirror and our first job then was to put the docking bar mirror on the docking bar. And in the zero g airplane, it was quite easy to go from the hatch to the docking bar mirror. I attempted to use this same technique, making sure that I was untangled and pushing off from the hatch with a very slight motion and reaching out and grabbing the docking bar. However, the tendency here, is if you do that you will float over the top of the docking bar by a couple offeet. So, you have either got to reach down and grab some RCS thrusters, which are not always readily available, and then over to the docking bar, or you have to put a translational velocity that points you down below the docking bar to get to it. This first try to get to the docking bar took a little bit longer than I expected, but, during this try there was some umbilical evaluation.

During this whole period of standing in the seat and throughout the umbilical evaluation, I was at times trying to get pictures of - using the EVA camera - either of the spacecraft, umbilical or the earth below. The umbilical evaluation was such that I actually went to the extreme ends of the umbilical at least twice. It was extremely difficult to get a foothold on the spacecraft. It was very difficult to get a friction foothold on the spacecraft, unless you were 90 degrees to the spacecraft surface.

I worked around the nose area a little bit and found out that, with the strength of one wrist and one arm holding on to the docking bar, you can not hold yourself in a static position. There was a tendency for your feet, or your CG, to drift back on over the top. You don't have enough strength in your wrist and your arms to maintain your heads up, feet down position holding on to something such as the docking bar. There was a tremendous tendency for your body to come head over heels. My arm and my wrist in a pressurized condition could not overcome the inertia of my body. I tried to do this with two hands. The only problem with two hands and the bulkiness of the chest pack, you cannot get a firm enough hold with both hands to exert a good wrist torque action. I was able to restrain myself in a desired position at the nose of the spacecraft holding on to the docking bar with one hand, particularly the left hand, and grabbing hold of the UHF antenna at the bottom. But, even after getting in a position, stopping all relative motion and just leaving go, you couldn't stay there. You just start drifting on up. The thing that amazed me was that I could not really hold myself with one hand, I could not control the torques that were generated through my body because of this slightly negative g. Holding on the same bar with two hands, a bar that requires the two hands to come close together, is very difficult, partly because of the pressure suit, but primarily because of the bulkness of the ELSS. You just can't get your arms in a position where you can exert that strength. I'm sure you could, with two hands, hold your body where you wanted to. The lever arm from the wrist to the CG of your body is so great. A force through that CG is certainly great enough that there is no doubt that you will go straight on up over the top.

Stafford — He would be out horizontally, holding on to the docking bar, and about 6 or 7 seconds later his feet would be vertical. If he let go he would go straight up. He had coils on the umbilical. It was immediately evident that the umbilical was putting a negligible torque on him. You would think that the coils would tend to roll him. One time he had several coils down over on my side, and when he turned and went straight up, he increased the number of coils in the umbilical. You increased the coils on the umbilical, and went straight up.

Cerman If there is any tendency of the umbilical, in free floating flight, to dictate your position relative to the spacecraft, this tendency is relatively minor compared to the force that tends to send you away from the earth. Any umbilical effects can be discounted when compared to the magnitude of results. The shorter the umbilical the more control you have of your position. I believe one tug from 25 feet will never get you to the spacecraft. It has to be a series of small hand-over-hand pull-ins. The main reason for this is because each succeeding slow pull-in corrects not only your translation, but equally as important, your attitude or your body rotation. What they are is 10 mid-course corrections from that umbilical to the spacecraft. Each one is necessary, if you quit at the end of the 9th one, you are going to miss. The type of man you need to work out on the end of the umbilical is a man whose arms are at his CG so that everytime he pulls in he induces no rotational velocities at all. This would give you the ability to see exactly where you are going all the time without any tumbling. Then you would have one less correction to do. Even so, one translation would not get to the spacecraft. It is possible that if you were straight above, straight away from the earth's surface, one tug might put you right to the spacecraft. Anywhere else, to the side and to the front of the spacecraft, it won't do it. You'll always go on up over the spacecraft.

Stafford It was very obvious from inside the spacecraft the difficulty that Gene was having outside trying to maintain body position and again this tremendous tendency for him to float up. In fact, at one time he was in from of the hatch, and he was out there in a semi-stabilized condition. I don't think I ever saw you in a complete stabilized condition. out there unless you were right in around the..

Cerman Right at the nose, I was.

Stafford I guess right at the nose at one time you were there holding on to the bar with both hands, but then he was over by my window and he slowly drifted back over and went up the nose. Not particularly toward the side of the umbilical but just slowly straight up.

Cernan — I feel that the umbilical has little or no tendency to dictate your position. Velcro Pad evaluation, I didn't get my total planned Velcro Pad evaluation, but I got enough I think to give us an idea of what effect that they have. I started on the Pilot's side of the spacecraft and I had one pad in each hand. The Velcro pads were down around my side and I started below my hatch and I put my left hand on a Velcro pad and I put a right hand on a Velcro pad. They were in good enough positions for me to get both hands on them. But just as I mentioned before about holding on to the docking bar when you tend to go tail over tea kettle. This is exactly what happened to me, my feet came over the top of my head and effectively if I would have let it go, I would have been standing on my head with my back against the side of the spacecraft. You don't have enough force between your wrist and Velcro pad to get any torgue action. If you are holding on to the bars at that point you would, but just the Velcro pad would not give you enough ability to torque your body back down to the position that you want it. So, as a result when I went tail over tea kettle, I started to pull the left hand off the Velcro pad and the Velcro worked very well on my hands, but right out of the pad...however I did pull the right one out and held onto it and did use it again a little bit later on the nose. I used it as I was going to the docking bar again a little bit later, but it appeared that the Velcro on the nose was not nearly as good as it was on the Retro Adapter, because I could feel some inclination for the Velcro to hold or stick but very little. Now it would have, if it worked properly, it would have stopped me there I'm sure; but it would have given me no attitude control, or no positioning. Even with Velcro pads on both hands, you have no attitude control.

You might hold yourself close to someplace but no attitude control. Your body would again tend to drift on up. You cannot exert a torque through your arms on the Velcro pad to maintain the position that you desire. Tom, why don't you mention about the docking bar mirror itself, during this period of time?

Stafford After Gene installed the docking bar mirror, I could immediately see that it was a wonderful tool. I could see a wonderful view of the spacecraft looking aft. I could see the spacecraft looking aft and I could see the earth below us and the sky above. I could also follow Gene anytime he was in any field of view aft of the docking bar mirror. I followed him all the way back to the rear of the spacecraft, and he went back to don the AMU. I think that the docking bar mirror is a real wonderful device. My only recommendation is the fact that it should possibly be larger. If it was larger it would give you more resolution as far as observing the outside crewmember. Now one

	disadvantage is sunset. The sun went right on the docking bar mirror and back in my face and nearly blinded me to nearly the same extent as the sun was in my face during the boost phase. I had to turn my head and close one eye to keep the brilliant sunlight from coming off the docking bar mirror into my face. It is imperative that the docking bar mirror be removed during EVA exercise and not remain in position.
Cernan	I worked my way back to the hatch area, took the EV camera out of its hole in the Retro Adapter and handed it to Tom and with remarkable speed, he changed the lens and the film pack. You did that real fast. Guess you didn't have any problems.
Stafford	No, this was all due to the training and practice we had before and the idea is that Gene and I had put little nylon tabs on the camera magazines. In the process of taking it out, you might pull one end loose, but could care less, because it has served its purpose and started the basic movement out. Also all the markings that we insisted upon as far as

the match up to the line where the lens would engage the camera body. This is very important, as far as having the availability of the Pilot to see these items, so that you can do it at a fast time.

Cernan — We reinstalled the EV camera. It was about the same magnitude of difficulty that we had before; I was able to get it in one handed but it was a pretty sticky operation. It should have more slopiness. I believe it just fits too tight into the bracket.

Stafford — Throughout the first day side pass, I continued to monitor the primary tank pressure and boosted it up to the required limits using the manual heater with a high watt heater. The duty factor there was approximately a ratio of 60 on and 30 off, which was required to maintain the proper tank pressure. One thing that was a great help in this case was the amber light on the Anunciation panel to remind me that I had the manual heater off. However, I just kept continually checking the pressure. We never got to the vent limits on the tank. The next item that occurred was the closing of the hatch for night time and for the work in the back in the adapter. Now throughout this period of time, we'd made the best estimation we could of the detailed activity with respect to time and at this time we were running approximately 5 to 8 minutes ahead of time. We decided that since we were both ahead of time we wanted to go ahead and go on back to the adapter so we could start working and always tried to maintain the schedule ahead of time in case we ran into any difficulties.

Cernan At initial hatch closing, I was in position at the forward end of the hatch. The leverage I used to start thehatch coming closed was the umbilical itself. I grabbed hold of the umbilical with one hand and I grabbled hold of the hatch with the other hand. I attempted to put my feet on it and actually just pulled it closed by just standing on it. I couldn't keep my feet on it with any regularity. I actually had one hand on the umbilical and the other hand on the hatch and sort of squeezed them together.

Stafford Where were your feet at this time?

Cernan My feet were somewhere up behind me. I am not sure. I know that they were up, because I was always looking down.

Stafford I could look through and look over at your face and I could see your arms and shoulders. You were trying to hold, your feet were up above a 45 degree angle.

Cernan The hatch was pretty tough to bring closed. The first movements came easy, and then in the middle range, it was pretty tough to get closed, but we finally got it within about 8 inches or so. Tom was pulling on the inside and I don't know if you were able to reach your hatch closing device or not.

Stafford What I was using was the lanyard we had put on to the device. It is a nylon lanyard that we had had that went from the center of the mechanism over to where we had snapped on the cabin vent valve lever. With that I was heaving with both hands helping Gene work it closed.

Cernan When we got the hatch closed, within about 8 inches, I was almost content to leave it there.

I worked my way back around the edge of the hatch where I then could take my right hand and hold the handrail on the Retro Adapter. I took my other hand and pushed down on the hatch to see whether it would go the rest of the way and it went with ease. I closed it solid on the umbilical. It obviously didn't hurt the umbilical, or do anything to the flow; not slammed on it but closed it up against it. I would estimate it was closed to within about 3 inches. I checked the hatch seal when we opened the hatch the first time, and I checked it when I came in to change the camera lens and film. Both times it was rubber soft. There was no apparent, either visual or physical difference, in the hatch seal during this period of time. At this time I moved on back to the adapter.

Stafford — You held on to the Retro section and gave me the go to extend the bars, before you got back on the adapter.

Cernan — And I think it was at this time, where I broke the D-14 antenna. Just as I was trying to get the hatch the rest of the way closed.

I am pretty sure this was the time that the antenna broke off. I stayed in the retro adapter area holding on to the handrail, and then told Tom to go ahead and blow the EVA bars.

Stafford At this time I used the swizzle stick to place the buff switch to the experiment position, then moved the EVA bar switch to the EVA bar position, to extend the AMU antennas, to deploy the bassinet, and also the handrails, and the footrails in the adapter. I was still in PLAT mode, and at this it seemed that I had to make a second pass, at the EVA bars to get them extended.

Cernan It was very evident to me when you finally got there, because the one thing I did see was the bassinet go. I did not see anything from the adapter, but I did see the telemetry antenna for the AMU about 3 feet from my nose. It is about 6 to 8 inches long and it has a relatively sharp point. It just came banging out. It was right there. I was holding on to the hand rails, and I am sure I felt it. At this time I was holding on heads down. Tom could verify this through the docking bar mirror. I am sure my feet were straight up in the air.

Stafford I checked his position at this time, and I had a real good view through the docking bar mirror, and Gene had both hands on the Retro Adapter bar, and his feet were straight up.

Cernan The antenna startled me. I knew it was going to come out, but it didn't dawn on me at that time to look for it. I heartedly recommend that we either paint a circle around that area, for future flights that have antennas that are extended in this manner, or paint a red mark or do something so that we are definitely aware of exactly where it is. Had I been on the other side of the spacecraft or had my leg or back near this antenna, I'm sure it would have gone right through my suit without any difficulty at all.

Stafford You got a slanted edge to the antenna.

Cernan I might, before we leave it, comment on this D-14 antenna. I broke it, down about 6 to 8 inches from the base. The antenna itself didn't really bother me. I think I broke it when I reached for it to hold on to it. I broke it off in a relatively jagged point, sort of like a copper tubing which surrounds a cable that goes through it. It is a folding antenna. The boom was retracted but there is still about 20 or 30 inches of antenna that sticks up. A small folding tubular type antenna with a little lead wire going through it. I broke it down around the bottom area, and the lead was still holding it together, al-through it tended to flop in almost any direction that I put it in. It did break off in a relatively sharp or jagged condition. As soon as Tom blew the bars, I knew that they had gone because of the antenna. I looked back along the handrails to the adapter where the umbilical guide should have been, that comes out when the bar is blown. At that time we had some difficulties. The bars did not blow or something was hung up, or we had some problem somewhere.

Stafford: I was also anticipating some large maneuvers in all three axis. When Gene would traverse to the adapter, because I would have to turn the control mode off. Now earlier during the umbilical evaluation, he drifted over to the top of the spacecraft back to the adapter. I was continually asking "Now let me know when you are near the thrusters, you don't want to cut them off." In a short period of time we pitched up over 30 degrees in roll, 20 degrees just within a period of 10 to 15 seconds. I went to PULSE mode control switch off, and went to control switch on, and then used PULSE mode. It took considerable effort in the pressure suit in the PULSE mode to come back to 0, 0, 0 where I could then engage the PLAT mode.

Stafford As expected we received some large excursions during this period of time when he was traversing over the equipment adapter until the time he got in position on the handrails.

Cernan I could feel the thrusters, but I don't recall ever seeing one fire. Neither do I recall actually seeing the plume of smoke from them. Did you feel the big spring-loaded foot rail extend Tom?

Stafford I could feel it when I hit the full down position of the electrical switch. I could feel a loud thud.

Cernan That was probably the foot rail that went then, because that was spring loaded.

Stafford There was a series of devices associated with it, but to me it was one real loud thud.

Cernan That's the one you would have heard because that's the big one. When I got back around the corner of the adapter I was very pleased in one respect because there was not one inch of our adapter separation plane, clust of material, hanging. It was a very clean adapter; although the edge was jagged as we saw in tests here on the ground. We've looked this over pretty well.

But there was not one bit of material hanging such as there was on Gemini VI and Gemini VII. When I went back to the adapter, what I saw was a footrail. I guess which was the first thing I looked for, the footrail was deployed. The handrail on the bottom side of the adapter was extended. The handrail on the top side, the side I was coming around, in the umbilical guide was not extended and the bassinet was about 75 percent on. It covered the AMU completely, but it was obvious to me that it moved about 25 percent in and was wedged sideways. At that point I didn't know what it was going to take to get it out, but it seemed extremely feasible to go ahead and try because I had seen these handrails deployed before. I had also seen footrails deployed before, and I knew the big problem was the footrail. The handrails were little or no problem. They came out with very small spring forces. I highly recommend that on future flights any time someone is working in the adapter and anywhere else in a spacecraft or Agena where those handrails or any spring loaded devices that are supposed to

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deploy, that might be hung up, that we might have to go after, that we know what their operation is. That is how fast they come out and what to expect, because this left no doubt in my mind that there was no problem in terms of getting hurt when this thing sprang out. I knew exactly how fast they came out. As a matter of fact when they did come out I just caught the umbilical guide as it swung around very slowly, and sort of extended it myself. To get the bassinet was much easier than I thought. I worked my way around the adapter. The one thing that concerned me was the umbilical. So I tried to hold the umbilical the best I could with my left hand and work my right hand on the handrail. I got about half way down the handrail towards the bassinet and the force I exerted on the handrail itself was enough to break the bassinet the rest of the way loose. By that time I was better than half way down the handrail because the bassinet was right next to me and it just floated by. I saw the center wire that holds it through the AMU into the spacecraft floating right behind it.

[redacted]

It was attached to it, but was part of it, and the bassinet just went floating by me. I could have just reached out and grabbed it. At this time the hand bar extended and the umbilical guide also released. It swung back sort of across my face so I caught it with my left hand and let it fully extend. I worked my way back and put the umbilical through the guide. Then I took a look down the adapter to see whether the umbilical was taut. There wasn't a kink in it. It was perfect. It was just laying right along those handrails all the way back. I pulled it, worked my way back in the adapter and put it in the umbilical clip that we've got on the adapter. I don't think that the umbilical clip was adequate because it did not have enough spring tension to keep the umbilical in there and keep it from sliding; keep it taut. We have to have something with more force, more strength, more friction to keep the umbilical from sliding. The bassinet came off all right. All it basically took was a few jerks on the handrail by me. The umbilical was marked so that we knew exactly whether it was taut or not. We had a black mark on the umbilical which was to coincide with the umbilical clip on the handrail. It was about 10 to 12 inches short at this point. So I again went back out to the edge of the adapter, and I took another look at the umbilical and I'm sure it was taut, and it was taut. I could see the bag coming out of the hatch and I knew that there was no kinks in the thruster area. I pulled it again; pulled it tight through the guide, pulled it tight through the clip, put it in again, and it was still 10 to 12 inches short. I was satisfied that it was clear of all thrusters and didn't consider this any problem. I knew there was more than a foot slack so that when I turned around in the AMU I wouldn't get caught short with the umbilical. As it turned out there was plenty umbilical at that end. I got back there and stood in the footrails and held on with both hands.

Stafford — I had Gene give me a mark when he was near the thruster area, so I could turn off the control power. Then I maintained control power OFF and no thruster activity until he was squared away and gave me the GO that he was clear of it. The torque that he generated in this short period of time, yawed the spacecraft to 150 degrees, and rolled it to beyond 90 degrees. I estimate about 110 degrees. So we were rolled passed 90, approaching the inverted position, and yawed 150 degrees going towards the 180 degree position. When I got the control power on again, I used PULSE Mode and some DIRECT to start bringing it back. This was a slow process. I brought it back to 0, 0, 0. I estimated the total time in here was between 30 seconds and 1 minute from the time that you said you were clear of the thrusters.

Cernan — I don't think I gave you a'clear'until I made sure the umbilical was in that clip around the adapter.

Stafford — It could have been as much as 2 minutes.

Cernan — The umbilical was (I was holding it in my left hand) basically floating while I was going back to get the bassinet free of the AMU. As soon as I got back there, the first thing I noticed, it was still daylight, was that we didn't have any EVA lights. I asked Tom to turn them on;

he turned them on. As I was facing the AMU, the right, or bottom light came on, and the left, or top light, did not come on. The glass was not broken. It looked perfectly intact, but it just didn't light. We re-installed the camera, the EVA camera, prior to closing the hatch, with the new lenses and the new film pack. We also installed the thermal cover. The thermal cover went on easy but we've got to find a new way to Velcro it down. It went on and it stayed on but it took too much time to take that Velcro loop and fasten it. What we need is something we can do with one hand, like squeeze a snap or squeeze two pieces of Velcro between your fingers. That can be handled very simply. We started on our AMU checkout, and the first thing we did was unstow the pen lights. The first pen light I got was good. I turned it on and I put it on the left or upper armrail. It stayed there without any problems. I took up the other pen light and turned it on and didn't get any light. I turned it off and on again and still didn't get any light, but I did not discard it.

I put it on a handrail also. So I had a good EV light on my right, and no pen light, and a good pen light on my left and no EV light. This was not anticipated to be a problem because the majority of the light was needed on the side that the EV lights were good. I had also gone through [illegible] procedure with no EVA lights at all, just pen lights, so there was no problem there at all. The next thing we did was connect the black tether jumper hook to the AMU tether ring. This was no problem at all. The next thing to do was unstow the tether bag and connect both orange AMU tether hooks to the ring on the umbilical tether. This was a problem. My procedure was to take the 25 foot position hook, which is a small hook, which I've never had trouble connecting before, pressurized, or in zero g environment. I took it out and tried to connect to the ring on the umbilical. I think the major problem there was the fact, that it is a two handed operation. It was anticipated to be a two handed operation, but I could not remain in the stirrup while doing it. I'd take two hands and I'd start to make this connection and by the time I got close enough to get the hook in the ring my feet would come out of the stirrups and I'd roll left. Always left, and if you figure this out it turned out to be up over the top of the spacecraft.

Stafford — Every time this sequence would happen I could feel his feet bang into the, your feet would bang up around the .....

Cernan — I know what you could feel, you could feel me let go and grab that other handrail and pull myself down into the seat.

Stafford — I could feel this torque and the thrusters would fire. Even in PLAT Mode, which is a fairly tight mode, the total roll of the spacecraft was oer 5 degrees. In other words it would start the acceleration in roll and the thrusters would start firing. By the time I could stop the acceleration, it was about 5 degrees in roll.

Cernan — I worked on this small hook for awhile. It appeared to me that the problem was not so much making a hook but reaching around the ELSS because it is bulky. But I've done this before, and it could be done, and I came within a cotton picking gnats eyebrow getting that thing on. Everytime you'd get close, you'd have to leave go with that one hand, and you'd have to stop the operation and grab yourself and put yourself in position again. I found out how to maintain position. If I bent my ankles up very rigidly, I could lock my feet in the stirrups. You just don't bend your ankles in that pressure suit. You end up bending your hips, your knees, your thighs and everything there is. This is where the work load begins to be generated, because I was just forcing. The work load was generated by maintaining position in the adapter. There was a tremendous amount of work to keep your feet in the stirrups. You just could not position yourself, and stay there, as I would have anticipated at zero g. You always come out and roll over the left side. Always roll to the right and roll to the top side of the spacecraft. Not one time did I get to the right side or to the bottom side on the right handrail. Not one time did I even get close to rolling backwards to the left. I finally abandoned the small hook and I figured it was not worth the future effort. I got hold of the big hook and with a still slight amount of difficulty, because of position, it's extremely tiring to maintain that locked ankle position while in a pressure suit; I did make that hook. I figured I possibly could make this 25 foot hook later after I'm turned around in the AMU, which I thought would be very possible or probable. If I can't, I'm still GO, because I have the umbilical, and I can go to a 125 feet of tether and I can go to it in increments, and just not pull it all at the same time. We could have still accomplished our 25 foot tether operation and 125 foot tether operation.

Stafford — It was at this time that I noticed a rapid increase in Gene's respiratory rate. Previously in all the training we'd done in the adapter work I'd timed his respiratory rate and he'd usually go between 30 and 35 at maximum. This is approaching a high work load. Now it was at this time that he said he was getting rather fatigued in trying to do this. I timed his respiratory rate at 40 per minute and possibly slightly in excess, and I think we both suggested at the same time that we take a rest.

Cernan Anything that we make just adequate at one-g concerning hooks and rings and probably almost everything is going to be difficult during EVA. And my recommendation particularly concerning our talk about the hook and ring problem, is to make things extremely easy in one g, so that they are at least adequate in zero g. And right now I would say that we should not go out of that umbilical if there are any rings or hooks to be made. We should not go out of the spacecraft without rings on the umbilical at least the size of a silver dollar. At least that size, and large hooks. We then proceeded to inspect the battery cases and they were intact. The rubber seals were on and the stowage of the RCS handles was just as it should be. They were stowed and in proper position and no problems there at all. About this time it was close to sunset. At about 10 minutes prior to sunset, we were SEF, and my back was to the west. I had been on medium flow this whole time and even with the increased work load it was adequate as far as cooling was concerned. Somewhere in here I started to get extremely warm on the back side from the thighs back up to the small of the back and subsequently, on the fingertips, particularly the first two fingers, first and index fingers. Just on the fingertips. The best way I can describe it, for about a 10 minute period prior to sunset my back from my thighs on up to my buttocks was just as if I was backing into a hot campfire or hot furnance or a stove. It felt almost blistering hot. I don't have any marks or any redness, but it felt blistering hot, and this is the first time that I went to high flow other than check it out. This is the first time that I went to high flow in the whole mission. And it wasn't necessarily because I was warm in the face. My front side was perfectly cool. I was not fogging or anything at this time. It was because my back got blistering hot. It got so hot that I just stopped what I was doing and turned to high flow and waited for the sun to go down. I just had to wait for the sun to go down because it was penetratingly hot.

Stafford It was not the heat due to grasping the bar, it was the heat out near the fingers?

Cernan Just the first two fingers. It was sort of right here that I was holding the bars. I was waiting there because my back was hot and I went to high flow. I said let's stop a minute and wait until that sun goes down to cool off. I tried to move my back away from the suit also just to do something to keep that area cool. And then I noticed my fingertips were hot. The sun was shining on them, but nowhere else on my hands was it hot.

Stafford Was the area on your legs where you had the Chromel hot?

Cernan From the thighs on up but the Chromel ends below the buttocks. My buttocks were hot and it was hot up to the small of my back. There was Chromel on part of that area and not on the other part.

Stafford How good is the Chromel, the extra insulation protection, against the AMU lower plumes where it fires right on it?

Cernan I don't know. It's a good question. We just paused, it was a rest period, not because I was tired but just because I got that hot spot on the back area. We continued when it got dark and the next thing to do was to unstow the attitude controller arm. I unstowed the attitude controller arm with a great deal of difficulty.

Stafford — I could hear him forceably heaving, nearly grunting. The spacecraft thrusters would fire, go through a rapid cycle of firing and the spacecraft would be torqued over 5 degrees or so. He was exerting an extreme amount of effort and we were really using a lot of fuel in PLAT mode trying to counteract the torques that Gene was generating in trying to unstow the controller arm.

Cernan — The main problem was that you could not hold your position. The stirrups were not completely adequate for holding your position so as to get the right moment to unlock the controller arm. We've done it in the zero g airplane. We knew it was somewhat of a task but we felt there'd be no problem in doing it. But here again, in order to maintain yourself in the stirrups, you had to exert a tremendous amount of force on the ankles, bending your body, just maintaining position, and, added to that was the work load of getting these arm controllers down. It's a difficult task. Plus, when you bend your ankles, lock your ankles in the stirrups, it shortens your reach. So, you are compromised, you have a long way to reach to get that arm controller down. If you lock your ankles in you shorten your reach and you can't quite get to the arm controller. If you get to the arm controller, then you aren't really too restrained in the stirrups. We had a one handed operation we used to use on getting these hand controllers down. I tried it with the left hand. I tried it with the right hand and I just couldn't get it with either one. I finally took both hands and just gave it one big hard heave ho and it came down. I took it down and turned it to what I thought was all the way and it popped out. I assumed it was in good shape and I lowered it all the way down. It stayed down fairly well at this time, but I wished I had a stronger spring to make sure it would stay down. It looked to me like it would tend to float up and lock in the up position.

But it didn't, it didn't forceably do that. It stayed down during this period maybe because I bumped it from time to time. The next thing I did was unstow the Velcro tiedowns that were on the bat wing on the translation controller, and I discarded them. At that time I felt it was not worth the effort to save them, which I had been doing in the EVA training and walk throughs. We had no use for them anyway so I discarded them. I just threw them over my shoulder. I got this hand controller down with a little bit more ease, less difficulty, than I did the rotational controller. I lowered it all the way down and it stayed down. I unfolded it and it locked in the proper position.

Stafford At this time I noticed on the event timer that we were starting to run behind schedule. Whereas we'd started out in excess of 8 to 10 minutes ahead of schedule, we were now running behind schedule. Looking ahead on the checklist I knew that we could make up some of this time because we still had the delta time increment for undocking from either the ATDA or the Agena and station keeping. I knew that we could make up a good 7 minutes so I was not concerned. The main concern was the effort he was having in unstowing the controller arms. At this time sunset was approaching.

Cernan — The sun had already set. I sat there for 10 minutes prior to sunset not doing a thing. I still was on high flow. I checked both of the hand controllers after I put them down to make sure that they moved freely in all directions. This was no problem. I checked the translational controller to make sure I was in VOX, make sure I was in a manual mode. Even though I checked it on the way down, after I got it down I again checked to make sure I was in VOX. It's pretty difficult to reach way down there in zero g, more difficult than it is in one g. I reached down there and verified I was in VOX. Somewhere in here I must have started fogging up but not enough to preclude what we were doing. I don't know whether I mentioned it at that time or not.

Stafford — Right here was when I became aware of the amount of fogging that Gene had. We always go through this sequence, oxygen hose, restraint harness, and electrical umbilical and right here he said "I'm having trouble seeing because I'm starting to fog up."

Cernan — Yes, I guess that's where it was.

Stafford — It was when you started to attach the oxygen hose.

Cernan — But I did get them all attached to the arm controllers as we had planned and in the order we had planned. We were in the experimental position on PROP gage, weren't we? I read the N_2 pressure, and I couldn't read it. The gage is small and I knew I'd have difficulty reading exactly what the numbers were. I knew it was high, somewhere around 3,000. Then I opened the N_2 valve which opened very freely and very easily. When I opened it I knew nitrogen was flowing because I could feel the gas vibration circulation through the valve. I could actually feel the nitrogen flowing. It was a nice feeling to know that it was flowing and you told me the pressure was coming up. You gave me about two readings, I think, as it came up. It locked up at about 450 didn't it?

Stafford — It went right to 450 and then eased up to 455 and became steady there.

Cernan The next thing I did was attempt to open the oxygen valve. At this point we were really stymied because I was certain that that oxygen valve was frozen solid.

Stafford I heard Gene complaining that this is the hardest oxygen valve he had ever opened.

Cernan I really had to grasp it with my left hand. I opened many oxygen valves on the AMU but never one that was this hard. I swear it was frozen. I finally broke it loose. Once I broke it loose I was again concerned because the whole handle rolled freely. But apparently it was opening and I did hit a stop. I forced it open against the stop. In this case I did not feel any gas flowing as I did with the nitrogen. I went down there and read the nitrogen and oxygen pressures again. The nitrogen pressure still was up on the high three quarters side. The oxygen pressure was just a little over 7,000. I could definitely read that gage. The thing that came to my mind was those oxygen valve leaks that they had. Well, the last guy to tighten that thing up was sure that it wasn't going to leak with this new OSS system in. It was tight. I don't contribute it to the booster phase, I just think it was tight, good and tight.

Stafford: Do you think a "T" handle would have made it easier instead of the round knob?

Cernan: No, I don't think it could ever be much tighter than this. I think the round knob is compatible. The round knob is much better because the "T" handle is a 180 degrees type turn. This had handles at every 90 degrees which is much easier to turn.

Stafford: More torque can be applied using a "T" handle.

Cernan: I think this was good enough, but it was definitely stiff. I thought it was frozen.

Stafford: At this time I noticed you had an increased respiratory rate and he was really tugging to get the valve open.

Cernan: Everything was really going fairly satisfactory, with the one exception that I was fogging up. My work load, I felt, was harder that it should be. It was harder than it should be because of position control or maintaining yourself in the stirrups in the adapter. All of our work had been built around the fact that in zero g, you would stay there unless you perturbate your body position with some external force or motion. This is not true. It was a continuous work load that just stayed put in zero g. I always tended to roll back over to the right and over the top of the spacecraft. So in addition to these other things it was a case of position maintenance. I released the nozzle extensions and they came down "bang," "bang." We deviated here as you read this we had to turn the selector switch on backpack and then we turned the power switch ON. The lights came on bright and strong. Two green lights. I knew we had power and we were GO for turning around 180 degrees in the AMU. It was a lot easier than in one g because you don't have to worry about this foothold. Here again the one thing that I noticed as I turned to the left, which was away from the tendency to drift and as I was turning down the tendency to drift up again. I definitely had to push away from the upper handle to get myself some roll motion in a downward or in a left direction. But as soon as I got far enough around where I could grab that other handrail then I had two handrails. I could then position myself up, down, sideways wherever I wanted. I saw the nozzle extensions that I just backed myself in. This I might add as far as the visual is concerned, as soon as it got dark I put up my gold sunvisor. This was all done without my sunvisor. We were still fogging up at this time. I don't recall how fast. Everything felt good and looked pretty good and I realized then how fogged up I really was because at this point I checked the mirrors and looked over my shoulder to make sure that my helmet was not hung up. Then this is a case where you just turn your eyes. I couldn't see through the mirror and I realized that it was because I was just fogged up on the left side, and I was fogged on the right side. I just looked this way through the mirrors and it was really beginning to fog up around the bottom and around the right side. I remained on high flow because my feeling was that on the nightside the fog was going to disappear. I really anticipated this. I was concerned about using the high flow because of the ELSS water but I felt that we wouldn't need the ELSS water if we didn't get defogged. I stayed on high flow with my sunvisor up assuming that we would start defogging here pretty soon. But maybe that's the wrong analogy but it didn't work anyway. We stayed fogged; in fact we got worse. I couldn't get my sunvisor down because the sunvisor cuts out all light. The next thing we did was make the AMU electrical change over. But I did position the tether jumper back by the way, just as we practiced during our walk throughs. It worked perfectly. I took the jumper back and put it on the left handrail which kept it out of the way. Not quite as neatly as it does in one g because in one g the tether jumper hangs down and they were tending to float around. It kept it up and out of the way. The best I could tell by just pushing the tether jumper away I could feel that I did not have it tangled. I couldn't see too well whether it was really tangled up but I felt I was in good shape. This is one thing that concerned me a little later though; not being able to see where everything was tangling. But the tether jumper was positioned and I tried one more small attempt to make the 25 foot tether. It didn't look like I was going to have much luck so I just let it go. Tom, then you turned off the circuit breaker and asked me if the power was off and it was off. The spacecraft power light was off in the ELSS. I took off the umbilical electrical fitting. It came off relatively simple. You were either going to get it off in a few tugs or it was going to take a monkey wrench to get it off. A few tugs in this case happened to get it off. And I had already positioned on the arm controller the AMU electrical harness and it was very easy to feel and find. I just could feel it fine and I was getting more fogged up at this time. This one light I had on one side eventually got to be, the best I could describe it, like a headlight coming out of a light fog. The main thing that bothered me about the fogging was that I couldn't use the mirrors. I couldn't look over and get enough vision. There was enough light lost through my visor fog into the mirrors and back to what I was doing that I just couldn't confirm; I could feel but I couldn't confirm what I was doing. The electrical jumper was made with ease because you could feel. It was right there in front of you. You could feel and you really can't miss what you are doing. I made the electrical change over and as soon as I made it, the RCS light came on and the tone came on. Well the tone may or may not have came on but it did come on in this case which was normal. I depressed the tone and the light stayed on and then we conducted a COMM check.

Stafford — As soon as Gene switched over in the VOX position I could hear the first part of his word and this was immediately followed by a warbling signal and all the rest of the time he was on the AMU I could hear this warbling that would drown out. In other words, the first word was audibly clear until this noise. This noise would continue until the transmission would stop. The transmission I would classify as marginal. The voice was very poor. I asked him to go to push-to-talk.

Cernan — As a matter of fact I pulled up the controller arm and just as we have done as you see me do over the knees so I could reach very easily the push-to-talk switch and went through the push-to-talk check and my side of the COMM post. push-to-talk was somewhat garbled but pretty good and it was certainly acceptable. It appeared to me however, that even on push-to-talk as well as on VOX, that when Tom came in he came in fairly clear but a good portion of the first part of his message was not there. When I went back to VOX I appreciated the fact that the VOX sensitivity in flight was more sensitive than we had ever seen in any of our checkouts. I alleviated some of this sensitivity. With my lips and tongue I pushed both mikes out as far away from my lips as I could. I was able to control by thinking about and working at it, I was able to control the VOX keying. And from that point the keying of the VOX was no problem to me. I could definitely key it and keep it unkeyed when I wanted to hear him talk.

Stafford: But what about this warbling noise. I could tell that the communication level had improved slightly but was still leaving out one or two words and there would be a warble all the way at the end and I could barely make him out. At this time we changed over was when he said he was really getting fatigued and was still fogged up. I came back and by mutual agreement I think said, "lets take a rest."

Cernan We did make the test dim light check and we got the tone and we got all the lights all checked out real well. As far as maintaining position, as long as I have my feet on the footrail and my hand on the handrail I pushed myself back into the seat and it was a very restful position. In other words I didn't have this problem of maintaining my position. With my arms I forced myself to sit into the AMU. It was a good comfortable position to rest but I was getting more fogged up all the time and we rested for awhile and then we continued. On the O_2 quantity I gave 85 percent, 15 percent is what I read which was a goal for us. There were no problems at all. Tom told me to go ahead and make the restraint harness. Normal procedures for making the restraint harness are taking the left hand side and Velcroing it and bring it around the front and Velcroing it around the front and letting it stay there. Then going down and getting the right hand side and bringing it up on the right hand side of the safety buckle is what it is or the female side and then reaching around with both hands and grabbing the female side with the right hand and the male side with the left hand and making a connection. And this is the point at which I realized it was really fogged up.

FCSD Rep — Gene when you were fogged up could you see the outline of the things you were working with or you could see a little bit?

Cernan — I could see outlines and I could see the handrail and I could see the light on but I couldn't see the handrail distinctly. It wasn't a solid fog, it was a light fog and I could see the handrail over here. I was fogged up more to the side than I was front. But when I really appreciated how fogged up I was, was when I took the mirror and I have always used the mirrors to get into this restraint harness. It just is so much simpler. I have always used it, and when I tried to use the mirrors to make the restraint harness, this is when I appreciated how fogged up I was because I couldn't see that front of the ELSS. I just couldn't see it. The vision restriction through my visor and back from the mirror in a low light back to the front of the ELSS I could not, just couldn't see it. I could feel it and I thought I could have made it but that's the point where I began! I could have made it, there's no doubt in my mind I could have made it and I probably could have gone ahead and made the oxygen connection too. I have done them all by feel before and I knew where they were and I probably could have unmade them. But I guess I may have asked myself a question at that point of where do you go from here and maybe you better stop and take a look at this fog and see what is going to happen before you get tooinvolved and too tied up in the adapter. So I stopped and I guess I told Tom what the problem was at that point or how bad it was. I feel that I could have made them and I could have unmade them but before I ever have gotten out of the adapter I have taken those mirrors, and I have checked every connection that I could see. I checked my position, I checked the AMU, and I think this is something you would want to do in any case. So I used the mirrors as an added factor of assurance that everything was connected in the right place. When I fastened the restraint harness I took the piece of Velcro of the left over harness that comes around and I fastened it around and Velcroed it back against the ELSS restraint harness so that inadvertently the restraint harness would not come open. This was part of our procedure and part of the safety factor of knowing that the harness would not unlock. These are the things that I could not see anymore, and I felt that I could have made them but as I say this is probably the one point where I stopped and asked myself how far can we really go before we get in trouble. I could have gone further and I probably would not have gotten in trouble but this was probably a decision factor. Tom had some comments at that time. I don't know if you remember all they were.

Stafford At this time when he was having difficulty making the restraint harness. I told him to take his time, to rest. I inquired as to his visibility and he said that he was completely fogged over. I said, "okay, let's just stop and rest a minute." His respiratory rate again was fairly high at this time.

Cernan We did then stop and rest and this was really not so much for rest. I was still on high flow. My main concern was are we going to get the visor unfogged and how far could we go with it. So we just sat there and rested. While we were resting I then began to take a look at the handrail. I figured I might just as well learn something else about the AMU while I can. While we were resting to see whether the high flow would take care of the fogging over the visor and allow us to continue, I did move up the handrails to see how they would react. To see whether they would unlock at zero g. I knew they would. I have done it in the zero g airplane. I pulled them up and played with the VOX switch again and just to confirm its position and to confirm the manual mode position on the AMU. I pulled up the right one also.

As I pulled it up I realized that the bat wing was not in the position that it should be in. It was turned slightly. I felt certain that I had extended this thing properly. I did turn it and it did pop out but it just didn't appear to me that it had turned enough. I tried to turn it with my one hand. I turned it to the extent where I was afraid I would almost break off the attitude controller itself. It just didn't appear right to me but I felt that if we did get this fog problem solved that there would be no problem. I had not completely made the restraint harness. I was only tied in with the electrical harness. There would be no problem untieing and turning around real quick and extending that arm and then continue with the AMU donning. This is one thing that I was just fiddling with while we were resting to see if we could get the visor defogged. As it turned out when I abandoned the AMU operation I did turn around just to verify that that arm was in good shape. I gave it one little twist and "bang," out it popped. I did extend it but somewhere along the line it just needed another quarter of a turn to get fully extended; to be in the right position. It really caused no problem and I could have done just what I did and continued on with the AMU mission if we were allowed to continue.

Stafford	I relayed the trouble we were having to Houston. I wanted Gene to rest in the adapter until the sun came up to see if this would alleviate the fog problem. I said it looked like we may have to give a NO GO on the AMU operation. The reasons were that the AMU communications were marginal but were probably still operative and that we were just going to standby until the sun came up to see if the visor would defog. When the sun did come up I called to Gene. When we started to get light in the adapter it became obvious that it wouldn't defog.

Cernan	When the sun came up I knew we had lost a great deal of time. I again questioned myself as to how long we could afford to wait for the visor to unfog and still have adequate time to make the AMU evaluation.

Stafford	It was obvious that after the sun had been up for approximately 10 minutes there was very little alleviation to the fogging problem. It was obvious that there could be a NO GO for AMU.

Cernan When the fogging first started in there somewhere I also noticed that my cuff gage pressure gage was fogging up. It fogged up to the point where I could see it well enough but yet I could just make out the difference. I could just about make out where it was. It was somewhere around 3. I knew that it was 3.9 as that was where it had been and it didn't look like it had moved its relative position. I could not read the numbers. It was fogged over even that day when we got in, and that night. The next morning after recovery it was filled with water. As soon as it got light my vision got appreciably better because I could see better through the haze or fog of the visor during the day than I could at night. I think this is obvious that you have better contrast. There were no holes by this time. It was just all fog. The questions I asked myself; we're now a victim of time because we were probably some 20 minutes behind time. Number 2, I now asked myself the question; "Is it going to get any better?" "How much really can I see and do with the fogged visor?" Number three, I didn't question the ELSS operation but I question the ELSS efficiency at that time. I was really wondering what it was doing for me, or to me. I can't say that I felt cool but I didn't feel hot either. If my visor was not fogged I guess I would have considered myself comfortable. A normal warm working day type of thing. I just wasn't sure now of what it's status was because it had done nothing to defog or get rid of the moisture in my suit or my visor. These are the things that probably all added up to Tom's and my decision, which was almost a mutual decision; "Well,we've come this far and we would like to go further but then what are the trade offs and what are you going to accomplish", and so at this point we decided to abandon the AMU operation.

Stafford Several things occurred to me. The fact that he completely fogged over and even if you de-fog a little bit we still had more items to go to continue the AMU checkout. We were behind time and if he would get out there and fog over while he was still hooked up to the AMU this could be a very bad situation.

Cernan

Now we're talking about completely fogged over; I mean the visor was completely fogged over. The vision was not zero, zero. As I said it improved in daylight over what it was at night only because you could see better not because the fogging immediately decreased. I could see through this mist in daylight reasonably well but the whole visor was coated with a sheet of fog. A damp breath was what it amounted to. So when we decided to abandon the AMU operation the first thing I did was get back on the spacecraft electrical umbilical. I might have done that during this period when we were actually deciding to rest a little bit to see whether we were going to get defogged or not. I think I did it during that period to increase our communication ability so we could talk about this thing. For sure I did it prior to our decision to NO GO.

Stafford

We talked about this. The communications were completely bad. We went back to the spacecraft umbilical so we could have good communication.

We had good communication and we sat there and talked over the total situation that we had. The time was to reach a decision and it was a NO GO situation because of the unknown factors. Being behind time and everything that was involved. The AMU configuration when I left it, while I still sat in the AMU in the adapter. I disconnected the tether and discarded it. This was so that I wouldn't get tangled with it coming around. I had the left arm controller down at this time and I left the right one up because I wanted it confirmed in my mind whether the arm controller was bad or whether it just had not popped out to fully extended. So I left it down, excuse me, I left it locked up in the flying position and I put the electrical connector and the oxygen connector which, I hadn't taken the oxygen connector off as I said I had felt around with it to make sure I could put it in if I so desired without any problems without the mirrors, and I put those both back on the arm controller. I also Velcroed the arm restraint back on the arm controller. The restraint harness from the right side was also Velcroed on the arm controller but it was in the up and locked, flyable position. I came out and turned around and with very little effort I gave that arm controller another twist and "bang", it popped out another inch or so and locked in what I considered the right rotational position. So I don't feel that there was anything wrong with the controller. I extended what I thought was full, but it obviously was not all the way. It was GO on the AMU and everything else in the AMU including pressures despite the valves that were a little bit tough to turn. Everything on the AMU that I found in terms of pressures, electrical systems, everything else that we were able to check out was GO in all respects. I came out of the adapter and took the umbilical out of the clip and came around and took the umbilical out of the umbilical guide. I took another look at the AMU. I wish now that I had taken a picture, but I guess a picture was not in my mind at that time. Though it was daylight I did not have any direct sun rays on my visor. As a matter of fact, my sun visor was still up.

I did not put it back down yet. It was definitely daylight and it was daylight before we decided the NO GO and I left it up all this time. Never once till I got back to the spacecraft hatch did my visor begin to defog. It was still fogged with this limited vision. I came back with relative ease around the spacecraft using a handrail and came back up to the hatch area still at high flow. Once I went to high flow I stayed in high flow mainly for water conditions and not necessarily for visor conditions or not necessarily for cooling conditions. I was not cold by any means but I had flow and I felt comfortable enough to go ahead if my visor was in good shape. I came back to the hatch area and opened the hatch. I don't recall exactly how I opened it but I feel certain that I must have had one hand on the handrail. The first few inches it came up real easy and then it was stiff again. It was stiffer but we got it all the way open without too much difficulty.

Stafford — One thing about the hatch during this part of sunset after Gene closed the hatch, I reached over and checked the hatch. With full force I could open it to the maximum length of my reach and close it back down as much as approximately 3 to 4 inches. I also checked the same function twice during the night time phase while Gene was in the adaptor. The length that I could open it was only 3 to 4 inches. So that portion of the hatch travel remained very easy throughout the entire mission.

Cernan I got back and actually stood in the hatch and I stood there for awhile and my sunvisor was up. I still hadn't put it down. I could tell at that time that I was beginning to get a hole about my nose area right between my eyeballs - right in here - and I could now begin to see without that fuzziness. I could see clearly without that fuzziness and then slowly my visor and I mean very slowly because it was still probably better than half fogged when we ingressed. It started to part right in the middle. It started to defog this way from the center if you took a book and opened it where my nose is and opened the pages left and right, that's the way it defogged over my eyes.

	When we ingressed it was still fogged from about the side of my eyeballs all the way around to the sides so when I turned my head or looked out the side of my helmet I still had this misty fog, typical visor fog. I could see straight ahead in this area. We stood there for awhile and at this time talked about S-1.
Stafford	Several items came up with respect to S-1. We knew that the fog occurred at nighttime.

Stafford

Gene and I discussed S-1 and this was approximately 20 minutes prior to sunset. Gene was standing in the hatch, still had the visor approximately 50 percent or more fogged over. We realized that the fogging problem occurred at night and in all probability would occur again during the next night, which would preclude him...but also associated with this, was the fact that we would have to do an ingress with his visor fogged over or wait until the following day to clear up which was probably in excess of what we had allocated on the ELSS. Also associated with the total problem, was the fact that we were very much aware of the large rates associated with a small movement that the Pilot would make outside. He could not stand in his seat without me holding him down. He would have moments generated there. So, during the time that the thrusters would be off, we would have fairly large angular excursions develop which would defeat the basic purpose of the experiment. So, the probability of fogging again during night time, the large excursions when the

Stafford thrusters were off, and the problem of a night ingress, the fogged-over visor, made us make the decision that we would terminate the extravehicular activities at that time and do S-1 from the inside.

Cernan We then had to clean up the hatch area, and go back and get the docking bar. We essentially had made the decision to ingress at that point. So, I took off, turned around and got the EVA camera and handed it into Tom. (I guess I never talked originally about putting the cutters, which I had in a pouch, back on the adapter handrail.) At this time they were on with Velcro and I took them off and discarded them, without any difficulty. I then went up to the docking bar to get the mirror. It took me two good trys to get to that docking bar again.

Stafford I had to help guide your feet out, to get you going forward at that time.

Cernan So, I got to the docking bar and then I got the mirror and discarded it and worked my way back up to the hatch. One thing, in retrospect, is the fact that, had I come out

Cernan

of the adapter with the AMU there would have been no problem working my way on the handrail to the end of the handrail or to the hatchrail, but getting from the end of the handrail to the docking bar (where I was going to make the umbilical connection to the nose ring and then warm up the thrusters) would have been a major task and could have taken anywhere from 3 to 30 minutes. I truly believe this, without any handholds or methods to get there. I thought about this Prelaunch. I anticipated doing just what I probably would have had to do, and that was to hold onto the edge of the hatch that was exposed and gave you somewhat of a handhold, then working from there to the RCS thrusters, and then to the docking bar. It sounds a great deal easier now and it really is a lot more difficult than I originally had anticipated it to be. My recommendation in this case is to go and get your propulsion system just as soon as possible and utilize it for all maneuvering from there on out. I did get to the nose, got rid of the docking bar mirror and came back to the spacecraft, handed Tom my EVA Hasselblad camera. I had taken a number of pictures off and on, both holding it with two hands and leaving it Velcroed to the chest pack and I don't know what type of pictures or what results we came up with, but I did take probably 25 or 30 pictures. Just about the time I was standing in the seat and I was handing Tom this camera, I saw a 16 millimeter film pack floating in front of me. It just floated up like a leaf floats down and it just kept going up and I just watched it until I couldn't bend my head any higher. I made one jab for it with my left hand and I couldn't get it. I missed it completely. I didn't even perturbate it, I just completely missed it.

Stafford — This was caused when Gene handed me the EVA camera. I was also pulling in slack on the umbilical and I turned in my seat to try to do this and my leg hit the Velcro pouch on the side where I had stowed the 'bug-eye' lens and this EVA camera film and both of them popped right out. I made a lunge for them and I think that I just barely tapped the camera film and imparted a spin to it and it spun right on up and out.

Cernan — It was just like a leaf, turning on its way up.

Stafford — I then tried to make a grasp for the'bug-eye' lens which was just out of my grasp and it slowly went right back toward the aft end of the hatch and right up without touching anything in the spacecraft.

Cernan — I never saw the'bug-eye'lens go. Never saw it go at all, but that film pack just...that was it.

Stafford — That was a heart breaker.

Cernan — That was it. We thought then (and discover now) that it was the film pack from the EVA 'bug-eye' lens camera. The umbilical routing, we might say now, was between the forward end of the hatch and the hatch holding device. This worked very well during the EVA umbilical evaluation and it worked very well for ingress. I just stood there in the hatch and Tom just pulled the umbilical in and apparently had no trouble with it.

Stafford — There was no trouble pulling the umbilical in. Now, at this time, Gene's left foot came entangled and wrapped around the EVA camera cord. This was the coiled utility light extension on the right side and the white knurled wire extension cord. This became completely entangled with his feet, so I had to reach over, take his foot, and position it around and have him move his foot, and untangle the cord. The cord was still stretched straight across the seat from the utility receptical on the right side, to my seat, where I had the EVA camera. After approximately two or three minutes to untangle the cord, I could see the only solution was to disconnect the connector, so I reached over, held the EVA camera underneath my arm, and then disconnected the connector. And then under the tension, the cord flew back over to the right side. I wrapped it in a ball and put it down between my feet. I then grabbed hold of Gene's feet and started working them down in there.

Cernan — It takes some definite teamwork to get the Pilot's feet back into the bottom of the cabin, because the tendency is to stand on the seat and almost sink to the bottom of the cabin.

You still have some way to go and you are so wide at that point. Your elbows are about at the hatch seal position and its pretty hard to work yourself back down in there. You can squeeze your elbows together and try to get some force and work yourself back down in there but the Command Pilot, with little or no difficulty, can grab hold of your leg and force you down there. Once you are down there, you then can get your footing and spread your legs out and stay down there. I checked the hatch seal on Tom's request just before I got in and the hatch seal was rubbery and the same color, same shape, same size and it looked like it never came out of its seal area anywhere. It looked just the way it did when we egressed the night before.

Stafford — During the ingress maneuver I asked him to close his feet together as close as possible and I reached over and grabbed his left boot and slowly worked it forward off the ejection seat down into the foot well and kept working up his leg to keep him going down in there and once he got in this position with his feet spread apart, he had enough force to maintain body position.

Cernan I handed Tom the ELSS and we had no problems with that, did you?

Stafford No, not the ELSS hand-off. The next major problem was the hatch.

Cernan Yes, well, at this point the visor had started to defog but I never completely defogged. It never completely defogged until after we pressurized the spacecraft, until I took the helmet off, really. It was clear around my eyeballs but outside them, I was still fogged. We started getting in position for a normal ingress. Getting the hatch closed in the center area of operation, was an extremely difficult job. I started halfway ingress and this part of the proceduce is to get your legs in position and start in and reach up and grab the hatch closing device and, the hatch swings closed part way and then you get the rest of the way in and you slam it on closed. Tom couldn't help me because he couldn't reach it. I guess you were pulling on the lanyard, hatch closing device....

Stafford — I had both hands at this time on the lanyard that was attached to the center part of the hatch closing device, pulling with everything I had and I could not budge the hatch.

Cernan — I couldn't move it. I had to actually physically stand back up in the seat and just keep tugging at the hatch and we finally got it through that hard area, through half of the hard area, where I could get more leverage on it, and I started ingressing again and as I got part way in, I realized that my tie down line had come undone when we took the ELSS out. It was floating up and out. We had the hatch open about a couple of feet, 15 or 18 inches. It was floating out so I wanted to grab it so we wouldn't get it caught in the hatch seal so I grabbed it, and tucked it back down. The next thing I saw floating up and out was a lanyard with a hook on it. The only thing I could think this was, the lanyard from the hatch closing device, was that it?

Stafford — No, that's our swizzle stick.

Cernan — No, it didn't go out, it was restrained from inside and the hook was floating up. The hook end was trying to float out of the spacecraft and it was restrained by the lanyard, so I grabbed it and tucked it up under something in the center panel here and made sure the hatch seal area was cleared and completed the ingress, trying to force the hatch more closed. We did get it somewhat more closed. As a result of this heavy hatch, I didn't get really down in as far as I had hoped to get on a normal ingress. I got in far enough where Tom could reach the hatch closing device and with his pulling on it and me pulling on the hatch, we were able to pull that thing right pass the last notch and hold it there and lock the hatch down. It was right up against my head, where at times I have had 3 and 4 and 5 inches clearance. I didn't have this, but the freedom of the hatch in the last 12 inches made closing the hatch bearable. If it was as stiff all the way down as it was in the middle ranges, it would have been a very tough proposition.

Stafford Again, at this time, the total cockpit was rather cluttered because I had the ELSS riding over the control stick, and the umbilical was coming in from the top. I had my hand reaching through this and had hold of the hatch closing device holding it down and Gene was over here at a peculiar angle, and I was trying to hold the chest pack down. So the cockpit was filled to the brim with the whole works. I would recommend that ingress never be done at night time because of the difficult situations you can get in to. You should always have a day ingress if possible. It is certainly feasible at night, but if you ran into any difficulties they could really be compounded in the night time situation.

FCSD REP — How would you like to do it while station keeping?

Stafford — I think it would be just about impossible station keeping.

Cernan — You could not ingress and station keep. You could ingress docked, obviously, but I'll say you could not ingress station keeping.

Stafford — You would have to drop everything....

Cernan — You would have to back off and then make a short re-rendezvous after you ingressed.

You could probably do that in a reasonable amount of time, like 15 minutes....

Stafford: If you have got a good position, say 100 feet or so. Once you start this total maneuver, all of your time and attention is devoted to it completely. Also, station keeping with a non-stabilized body through approximately three hours would be a very difficult task while you are going through the proper preparation period for EVA. It would detract greatly from the EVA preparation period and also would require a considerable amount of fuel, even if you widened up your deadbands as far as your station keeping was concerned.

Cernan: I got a couple of additional comments. I highly recommend that the deck of the cabin on the Pilot's side be covered with Velcro or some sort of frictional material. Don't put Velcro on the Pilot's boots, but use some material that will give you something in a way of friction for ease in ingress, because one of the problems of ingress was that my feet slipped on the metal deck. I kept slipping back and it was difficult to work my legs up in there. If I had something to restrain my feet in terms of just plain Velcro or a piece of rubber or something down there, it would have made it an awful lot easier. One other comment I would like to make is, the ELSS emergency oxygen supply was somewhere around 7600 when we donned the ELSS and, in case anyone wonders why it got down to 68oo, this is the reason: At 20 minutes before sunrise, we went ahead and made our final preparations on the ELSS. Part of these final preparations are: turn the battery switch on, check out the emergency oxygen system. Once we turned it on, we left it on. But, I left my visor open for a few minutes. As a result, the ELSS was flowing emergency oxygen. The requirement was for it to flow and it was flowing and the light was on. Until I close my visor and build up a back pressure, that regulator valve will continue to flow. So, when I actually egressed, I egressed with 6800 pounds and never used one ounce of emergency supply oxygen throughout the whole EVA period.

Stafford Well, the hatch closing device pulled the hatch ridge down into the seal and past the last stop on the ratchet or the hatch assist device. Originally, I thought the hatch assist device didn't have the proper spring loading, because it was free, and right at the last, I realized that we pulled it way past what was required to close the hatch. At this time, Gene started the crank on the handle and had some difficulty in operatiing the handle, because of the angle.

Cernan Yes, it was because of my position in the seat. I hadn't got down in the seat as far, (it was obviously adequate to pull the hatch closed because we did that without any problem) as I could have been. As a result, it was just a lever action of the left arm but the hatch started locking immediately. The first couple of pulls were very easy, and then I felt the thing go over center and Tom said "It's locking". Then I pulled it about three more times up against the stops and left it that way until we pressurized the cabin, at which time I put the dogs back in the neutral position.

Stafford — As soon as the hatch dogs started to move I could see this on Gene's hatch and noticed the movement of the hatch with respect to an index we had placed on the front part of the hatch, so I could judge very when the dogs traveled over the center and into the completely locked position. We placed the cabin vent valve to the full up position and within 30 seconds you could see the pressure starting to rise.

Cernan — Why don't you go through the procedures you used on the ELSS, for instance to go to 'high flow' and then 'bypass' and then 'shut the repress valve off' and 'use emergency oxygen'. I don't know how much we ended up with.

Stafford — We were in high flow.

Cernan — We were in high flow all the time.

Stafford — We were in high flow and continued in high flow and as soon as the pressure built up to 1.0 PSI, we checked and everything was going good. And by the time it approached 2.0 PSI, we went to the bypass position to increase further the amount of oxygen flowing into the cabin and everything looked real good. At approximately $2\frac{1}{2}$ PSI, I turned off the cabin repress valve to save the spacecraft ECS oxygen and used the emergency bottle to completely repress the cabin, which it did adequately.

Cernan During the bypass, I know we got flow sharing because I heard the tone. I heard you turn it off, so we got emergency flow sharing along with the repress valves oxygen.

Stafford I looked over at Gene's face plate, and I saw that it completely fogged over again during the ingress maneuver, so that the amount of effort extended there again fogged his visor over completely.

Cernan By the time we repressurized the cabin, (Tom depressurized automatically) I was wedged in the pressurized unit in against the top of the seat. I could unlock my visor and I could vent it so very slowly but it seemed like it would take an hour to vent it, so I told Tom to take my glove off. So, we actually depressurized the Pilot by taking his left glove off, rather than by opening the visor.

Stafford — You could not reach the visor....

Cernan — I could reach it but I couldn't get the bailer bar up. It was unlocked, but I couldn't get it up.

FCSD REP — Are you a heavy sweater or do you sweat a lot when you exercise a lot?

Cernan — From what we've seen here and all our EVA preparation, yes, I generally do perspire quite a bit. I don't know how I compare with other people, but I always end up with a wet suit.

Stafford — From the EVA activity that I've done, on Gemini VI and the pressurized work I've done on this one, I perspire every bit as much as Gene does.

Cernan — My suit was of course, wet from top to bottom; my helmet was soaking wet. My helmet was still wet the next day when I put it on for retrofire, so that it was very difficult to even get on. The suit was wet and that night when the cold air was flowing through it I was actually cold. I was shivering that night, at times because of the wet suit.

Stafford — I think that this has brought out the fact that he did fog over completely during ingress, brought out the fact that an ingress at night would have been even far more difficult and probably the degree of fogging would increase considerably.

FCSD REP — We will start on general EVA questions now.

Stafford — With respect to the checklist. I thought that the checklists worked very well. They were adequate: they gave us a good indication of how we were doing with the total time-line functions, whether we were ahead or behind. I think that the only way to go with an EVA preparation and an EVA flight plan is to have a detailed checklist and check off each item as you go.

Cernan Unstowing of EVA equipment I think went real well. I personally feel that the work that we put into the EVA walk throughs was well warranted, because it resulted in a clean cockpit and everything went real smooth.

Stafford The reason for the total effort going so smooth and as well as it did was strictly due to all the time and effort we put into it.

Cernan A lot of work put into the checklist, and we had a lot of people following the functions of this whole EVA operation, which really in itself is a whole mode of operation. It desires the full time work of the people that have been working on it.

Stafford The 16 millimeter camera I would like to cover under a separate area. There are major deficiencies in the 16 millimeter camera and as far as the equipment goes will be covered, both EVA, and non-EVA under a separate item.

Cernan Hoses, connectors and cables, I think were all right. Although my foot did get tangled in the camera cable during ingress, this is the first time it's ever got tangled and I think the routing was suitable in the way we took care of it. It was clean. The one Tom and I would like to make is that we tape all of our oxygen connections, from the ELSS and to the Pilot's side and to the cuff, to the gloves, everything. I feel that if we're going to continue to tape as an added safety factor, we ought to get some better tape. I felt this way before the flight, and I definitely feel this way now, that the tape we have is not adequate because its adhesive qualities are not good enough for this operation.

Stafford Until a different type of connector is designed where you have a positive lock on a lock, it is our recommendation that all connections be taped as an interim safety factor.

Cernan We had no indications of any connectors attempting to open or found locked, on either one of us on either the ELSS, the Pilot, the gloves, helmet, anywhere. So everything actually performed the way it was supposed to although it was taped. The umbilical, as to getting it in and out of the spacecraft, was the Command Pilot's job, and he didn't have any problem. He just handed it up and up it went.

Stafford Handling the umbilical going out for egress was very easy, and coming in for ingress was rather bulky, and I managed to place the umbilical between my legs and hold it.

FCSD REP How about the ELSS, was it pretty easy to handle too?

Cernan Handling the ELSS in the cockpit, although you know it's bulky, and it's got a lot of volume; the fact that it no longer had 40 pounds of effective weight, as far as we're concerned made it very easy to handle.

Stafford Now one thing again that brings out the real use of the PLAT Mode is the stabilized situation on ingress, if you have a dead control stick. If you had Attitude Control Power Off, you would have drifting rates that are going to go up a considerable degree. If you wanted to keep the stick inert from that point of view the PLAT Control Mode is a very definite way to go as far as the use of the spacecraft control mode during this function.

Cernan Hatch closing devices were installed and worked adequately, no problems.

Stafford The hatch closing device was good as far as the final closure. There needs to be a major re-design in the hatch closing device, so the Command Pilot can close the right hand hatch from a full extended position. It is impossible under the present configuration to do this.

Cernan The Pilot has to get the hatch closed by himself, to within 10 to 12 inches of total closure before the Command Pilot can even begin to help him. Donning the helmets went very easy for both of us. We each got our helmets donned and locked without any problems at all. No problems, visor, gloves and wrist mirror all went on real easy. Suit integrity checks went well.

Stafford Yes, suit integrity checks went according to the procedure.

Cernan I don't think we had a drop in either suit, did we?

Stafford No.

Cernan No effective drop in either, that you could read. ELSS checkouts went well. Spacecraft mirror was not used by either one of us during the process. Dexterity with pressure suits - no comment.

Stafford There can be some major improvements in the next generation of suits over the mobility of the present pressure suits we have.

Cernan The Pilot had a pressure suit that was abnormally tight in the unpressurized condition. Not uncomfortably tight, but abnormally tight. It was made that way with a purpose in mind, because its primary function was to operate in a pressurized condition, with a minimum amount of bulkiness and as much dexterity as you can handle. This worked out great The suit was, except for the restrictions of the neck ring, and the restrictions of having the bulky suit, without pressure points. Because of making the suit tighter, the legs were tighter, the back was tighter, the suit itself is a hindrance but, the fact that this suit was tighter maybe it might have been if I wasn't going to go EVA did not make it uncomfortable. The EVA gloves which were finally settled upon for this flight were okay. They fit extremely tight, were difficult to get on, which again resulted in a glove which gave you some dexterity pressurized. My feeling now though, is no matter what you have on your hand, it takes something away from your feel, and it takes something away from your strength because you're fighting the glove, and if I had to wear the gloves that were originally designed for the Gemini IXflight, I would consider them a major point of concern, just from the standpoint of being able to maneuver and handle yourself, in and around the spacecraft, being able to install cameras, being able to do so many things because of bulkiness and strength required to clinch your fists with those gloves and the lack of feel, the lack of dexterity would have been a major problem. There's no doubt in my mind, I think the gloves we have now are adequate, but any more bulkiness in the gloves for any other flights will be a big problem. I strongly advocate even taking a further look at the gloves we've got and trying to reduce the bulkiness on the basis of improvement in material. One of the major disadvantages of the gloves. as I think back is the fact that the glove is not built so that, in a pressurized condition, it's molded to the natural position of your hand. I think the glove should be. The fingers and the thumbs should be curved, and positioned such that in a pressurized condition it gives you the natural position of the fingers when the hand is hanging limp from your side. Not in the flat stretched out position where half the work is to put your thumb and fingers in what you might call a natural resting position.

Stafford: The systems integrity checks went very smoothly and just as planned.

The morning of the third day we had considerable debris in the foot well pouch, and we anticipated it would expand under zero pressure to a large volume.

So I had the footwell pouch in my lap when we depressurized the cabin and it did expand and it was jettisoned.

Cernan One of the major pains, if you want to call it that, in EVA preparation was having to unstow and restow things that would expand in the vacuum atmosphere in the pressurized aft box on the right side. Well, as it turned out there was only one set of articles that we considered prior to flight and during flight that fell into this criteria. It took a great deal of effort and a good bit of time to stow these articles, and they happened to be the M-5 urine sample bags. We had to take each one of those many, many bags, and put them into another type of bag and then turn around and stow them in the pressurized right aft food box. If it wasn't for that, we'd probably even have saved more time in EVA preparation.

Stafford All items in the de-briefing guide, that are now listed we have previously covered in our de-briefing. The last item we will mention is the extravehicular gear restowage. All the items that came out of the Command Pilot's left hand aft box we attempted to restow in the same box. The umbilical was readily stowable in the umbilical bag. The Command

Pilot turned around and tried for approximately 10 minutes to stow the bag back into the left hand aft box, and was unsuccessful. I had no way to get the angles, the force into it that I could. So, all other items that came out of the left hand aft box were stowed in there and later on, some cameras. The umbilical bag was maintained on the floor of the Pilot throughout the rest of the mission and reentry.

Cernan It created no problem at all stowed in the footwell. The ELSS was stowed very easily. We put the plugs in and Velcroed the little rings on the tabs as advertised and the ELSS did not get jammed. We had no problems with it at all. Camera restowage was really not done at this time because we used most of the cameras for for the next day. And that about sums it up. I might just make one additional comment about EVA. That is when you are to jettison something and giving something a retrograde motion, it is far easier to do than I ever anticipated. With just a flick of the finger, things moved away from you and I feel that to jettison something like the ELSS or the AMU would be a very simple task. Much more simple than I anticipated. I advocate doing all zero "g" ingress work in the airplane. In a tired (or after a high work load) configuration, because this is a realistic mode of training. Opening the left hand hatch, I think needs another look. For the Command Pilot to open the left hand hatch, with as many things as he has in his footwell and in his lap, and as many things as he's trying to do otherwise, it's almost unrealistic to even think of. It would have to be some kind of dire emergency which I feel would probably be compounded by opening the left hand hatch. It might be considered and looked at a little more closely on future flights.

Stafford We thought that EV Prep while station keeping would be a very time consuming task, and degrade from the total effort of EVA Prep, for the amount of effort that is going to be required for the station keeping phase. You might be able to make some advancement by unstowing a certain amount of the EVA gear prior to a rendezvous or prior to station keeping. Station keeping is a full time job. It is very difficult, if not impossible, to station keep and to perform EVA tasks at the same time.

Cernan My recommendations in general on the EVA are, Number 1: Go get your propulsion system as soon as possible and utilize it. Don't depend on the umbilicals or tethers for maneuvering, or getting back, or to or from any one place to another. Number 2: Where you do have to traverse around the vehicle, or the spacecraft without a propulsion device, you need hand holds which you can utilize with both hands at the same time to overcome the negative "g" positioning problem that I feel is definitely there. Why, I don't know, but it's there and it's definitely a problem which we have to cope with in orbital flights.

FCSD REP — Well, I've noticed you have several times referred to a sort of negative "g" of ..., joking I guess, but could it be possible that you could roll the spacecraft upside down, and ...

Stafford — I don't think we could really say at this time.

Cernan — It would help in one area, if you rolled the spacecraft up, up and down you still drift up and away from the earth so instead of drifting to the top of the spacecraft, you'd drift to the bottom.

FCSD REP — No, I'm talking about keeping stuff from floating up out of the cockpit and things of this type...

Cernan — It might help, and it also might help on ingress, but if you're trying to ingress, there are so many perturbations from the Pilot on the spacecraft that if it's not in PLAT Mode and stabilized you're going to perturbate it out of that heads down position anyway, and yet the PLAT Mode won't keep it in the heads down position.

FCSD REP — What I'm saying is do you think it would be worth while to try this on one of these other EVA missions, to see if there is a difference, possibly. If you could ingress upside down...

Cernan — I think it would be worth while, but I think it would be also worth while to just fly upside down for a period of 30 minutes or so, controlling the spacecraft not even EVA and just watch what the tendency of articles within a spacecraft is, because everything inside the spacecraft and outside the spacecraft, on our flight floated away from the earth. Both EVA Pilot and pencils inside the spacecraft, film packs and umbilical, everything we had floated away from the earth. You're right, it might be worth a look at, and I think we probably should look at it with both hatches closed and roll inverted for a long period of time, maybe 30 minutes. Just to watch what the tendencies are, for things to do.

FCSD REP I've noticed here, throughout your discussion, things always seem to go up and away from the earth.

Cernan This was the major problem in maintaining position. You had the capability to stop your relative motion, stop your attitude rates, and stay at the nose, or stay at the hatch, just without any perturbations at zero "g". Theoretically you should be able to stay there indefinitely, but this requires a continuous restraint on the part of the EVA Pilot to stay in any position, to keep from floating up.

FCSD REP Well, I've noticed in monitoring your conversation and even on the radio on the ground I get this impression that everything just wanted to float up out of the ....

Cernan I think the tendency there.. we all had after Gemini IV, when we saw an EVA cover glove float out. the spacecraft, we say look at the out-gassing of the spacecraft. Look at the out-gassing out of the hatch, so the glove went out. But, this is not so. Now we had no explosive hatch opening when we opened the hatch in the first place so to me this says that there is very little out-gassing at all. Everything we had, and everything we did, every tendency to go anywhere was away from the earth.

I would like to get an answer from somebody.

FCSD REP — Maybe on one of these later flights they might try ....

Cernan — Well, it can be tried, but you see there is a problem with the spacecraft. The automatic PLAT Mode, which holds you heads up, and without an automatic mode, the perturbations of the Pilot getting in are going to roll, and yaw, and pitch the spacecraft if it is drifting. So you won't stay heads down anyway.

Stafford — What you can do is just do this, in other words, put it in Rate Command.

Cernan — Yes, probably could.

Stafford — Roll inverted, Rate Command, and then just look and see what happens. And you can have the Pilot come in from outside . and see which way he goes.

FCSD REP — If he goes to the bottom, there might be something there that you can look into further. I mean if everything reverses, if you go up side down, and if everything wants to go to the bottom of the spacecraft, then something could stand a little scientific investigation.

Cernan — That's right. We've heard that things tend to maybe float up before but we've never considered it as a real problem. But when you're talking about putting the mass of a man out on the end of a lever arm where his wrist is the restraining torque factor, then you've got a problem and that's what we had.

a good 10 to 15 minutes of that day pass. As I egressed from the adapter to the hatch and when I was standing in the hatch area I still had the gold visor up hoping that this might alleviate some of the fogging. I put it down when I went forward to get the docking bar mirror and I left it down throughout egress.

Question — The low emissivity coating was rubbed off the visor. Do you have any idea when this may have happened?

Cernan — I think it probably happened post EVA because prior to EVA I had been very careful with the visor. I took the helmet off soon after launch. I took the helmet off at Carnarvon. As soon as I took it off I put the EV visor back on the helmet and I slid it down so the EV visor was actually covering the pressure visor. It was protected. The EV visor had its cloth covering over it and I put the whole works in a bag and left it there for the 2 days prior to EVA. It was never touched again. Then during EVA the helmet was handled. I was conscious of this, had handled the visor just on the edges with my finger tips. The helmet went on very easy so we did not smear, rub or even touch the visor putting the helmet on. It went on and locked very easy. Then it came down for pressurization and was covered again right after egress when I was standing in the seat. I feel that because I was conscious that this coating did and could rub off, it was something I mentioned preflight, the only places I ever handled the visor was around the edges. Most of the time I didn't even have to touch it there. I just handle the bailer bar. And the helmet itself was handled very little prior to EVA. At post EVA I am sure I had my hands all over the visor when I opened it, when I took the helmet off. I know when I rubbed it off. The visor was dirty when we put the helmets on for retrofire. I took a tissue and I wiped my visor and I bet that's when most of it came off. I saw you wipe yours and I wanted to see if mine would come clean. I took the tissue and I wiped the whole visor prior to retrofire to get a clean visor. It didn't do any good.

Cernan Tom was my thermozipper cover closed?

Stafford	Your thermozipper cover was closed. I saw it. I saw you from all different views and it was closed. Underneath, it was flat between the two parts of the suit. The zipper was in the middle and your parachute harness was around the outside.
Cernan	That takes care of those questions.
FCSD REP	We can move on to 52 hours 36 minutes. This is the Hawaii pass. I believe there is a problem, something along in there with the RCS ring A circuit breaker.
Stafford	Right, the ground called up about the RCS ring A circuit breaker.
Cernan	This is post EVA.
Stafford	Right away we looked up and it was knocked off. I think it was number 3 RCS A thruster and it was knocked off. This had been knocked off during the EVA. I called several times to Gene when his feet got over near that panel. I said watch the circuit breakers because I could see him kicking inadvertently. He couldn't help it at all. A couple of times I grabbed his feet and kept them away from the scanner heater circuit breaker. Because

I'm sure even with the guards on there you could get your boot around there and kick it.

FCSD REP — Tom, do you remember on-board propellant quantity read out at that time.

Stafford — It was in the ball park. I was down to about 3 or 4 percent.

FCSD REP — Was it that low?

Cernan — In our new configuration status post EVA they asked me what the physical configuration of the AMU was. I told them how I left it when I egressed the adapter. I jettisoned the AMU tether and the left arm was down. The restraint harness and the oxygen cable were velcroed to the arm and the electrical cable I felt certain was velcroed to the arm but I didn't confirm it. The right arm controller was up because I put it up to get the data that the arm was functioning properly even though I wasn't going to be able to use it. I did give it one quick twist and it extended fully and locked in the proper position so I left it there. I left it in the up or flyable position. The restraint harness on the right side was velcroed to that arm and the battery switch was left on and the T/M switch was left on. I saw no reason to turn them off. It was a case of feeling around to get them so I didn't feel it was worth the time to turn them off. And that was the status of the adapter.

Stafford We got a maneuver up date for our orbit trim immediately after we ingressed.

Cernan 25 feet per second and they said we see our regular pressure start down. We never saw our regular pressure start down. We burned 25 feet per second with out any problem and the residuals were within limits.

Stafford We were in PLAT Mode, BEF and PLAT Mode, BEF did not hold us as good as Plat Mode, SEF for some reason. We did have a couple of residuals but we left most of them in. The ground could put it in. This wasn't a precise maneuver for a rendezvous. Mainly we wanted to get the fore-aft component to lower our perigee.

Cernan We purged the fuel cells normally. I won't say anything more about those. The AMU pressure was expected to rise. We questioned whether or not they wanted us to jettisoned it or not. We figured we could jettison and then thrust about 1 foot per second and leave it. The ground felt that it was better to leave it in the adapter. We monitored quite frequently the pressure. The temperature stayed constant about 65 degrees and the pressure slowly built up from about 450 or 455 to 480, 490. By the time we retrofired it was exactly 500. This may be the extreme top of the gage limits but that's the maximum pressure we ever read. We talked about that burn and the update maneuver and the burning.

Stafford Hawaii pass we didn't do any more D-14's after that one time.

Cernan We didn't do any after EVA.

Stafford We did do an S-1 experiment. I think we have already discussed the S-1 experiment. We are all certain that the data we obtained was far better for the experimenter then what we would have obtained had we stood in the seat because of the inability to hold yourself in one position and also to turn the thrusters off. Just a light motion of the body would cause the spacecraft to rotate.

Cernan There is a question here, "Were we rushed?" We were not rushed. Internal lighting was completely off.

Stafford Except we had to have some red lights on. Except for the red light on the attitude indicator control and the attitude indicator and the red light on the GET time. We were not rushed. The factor that is going to disturb these films more than anything else is going to be the moon. We tried to take pictures in the areas away from the moon. The milky way pictures we could only go up to about our zenith where the moon shine really effected the picture.

4.13 Reentry Tape Load

Cernan The procedure was described previously. Reentry tape loading. We received a procedure prior to loading our reentry module 4 to go through to make sure that automatic start comp cycle that was initiated during the first day, first rendezvous would not plague us again. We went through this procedure and had a question or two. The procedure was revised, when we got to the automatic loading of the tape, it went in properly and module 4A was loaded and verified. Then I verified it on module 4 Bravo later that night before we went to bed. The next morning I reverified it again on Module 4 Alpha. The 3 reverifications were exactly as they should be. No problems at all. The Comp lights came on when they should. The auxiliary tape system worked properly. We went through a power down check list and gave a crew status report. The F-11 experiment horizon only. This is the only portion of any experiment which we did not do. The reason we did not do this was that the camera gear had to be stowed some place prior to EVA. It was stowed in the bottom of the right aft food box because we had to have easy excess to the gear that we put on top of it such as life vest and some of the other things for post EVA. We did not feel that for two pictures it would be worthwhile getting back into that aft box. It is about an orbit exercise to get back into the bottom of that right aft box. We covered experiments pretty well I believe. We saw no unusual phenomena, occasionally a meteor. They happened so quickly and are gone so fast you can never take pictures of them. We received our PLA up dates. We had another normal fuel purge. Occasionally as I say if the ground did not give me a cue to purge one section before the other then I alternated them on my own. It worked out real well. We slept very well this third night. It took the Pilot a couple of hours to go to sleep but once he went to sleep he slept well. This time I took my light weight headset off and the Command Pilot monitored UHF. I wasn't fully awake until Carnarvon. Occasionally I woke up and looked around or checked AMU pressures but I didn't wake up until Carnarvon the next morning. Tom was startled and his heart rate went up about 40 beats when Carnarvon called him.

Stafford — It went up about 35 or 40 beats.

Cernan — The noise never changed in the spacecraft at night. It was always a low humming buzz with a word some time. It's like you might see on TV, Lost In Space.

It's quite and nice to sleep. The only thing that disturbed my sleep the third night might have been the transition from the night to daytime. Where the sun filtered in around the metal plates we put over the windows we talked about how to alleviate that. When we woke up at Carnarvon we had fuel cell purge. Went through a power up and alignment. Tom, do you have any comments?

Stafford

We had a fairly large yaw and roll rate during the night. When we woke up I got the IGS power on, the ACME BIAS on, went right to PULSE mode and our attitude 0, 0, 0. I got it aligned, then turned around later on to 180 yaw and alined for the complete revs. Then between that we went down and shot some strip maps across the African continent, Indian Ocean since we had a couple of packs of film left.

Cernan

Propellent was holding out very well. As I recall we still hadn't gone on the Volkswagen tank. Tropical ~~storm~~ observation. We were asked to look and see if we could see a tropical storm which ended up to be Alma developing in the Caribbean. When we did take pictures of what we thought was counter clockwise rotation it was completely surrounded and covered by Stratus clouds. It didn't look too intense. The whole area seemed to be just completely clobbered over.

FCSD REP — Do you think you could identify this as a storm with your knowledge of the weather?

Stafford — I wouldn't have called it a hurricane.

Cernan — I would have called it a small counter clockwise low pressure area.

Stafford — There were lots of clouds but not the definite lines associated with a hurricane.

Cernan — Normally when you see a hurricane even the counter clockwise streaks go into the Cirrus clouds.

Stafford — In this one there was so much high,overlying Stratus we couldn't really pick out the individual pressure patterns.

Cernan — We received the reentry load the night before. was a good one. We had TR counting and it was checked manually. We received another load the morning before retrofire, copied it down and it was a good load. It was checked manually. We checked TR time a number of times. We were updated on our Event Timer and our GET. All three checked right down to the second. Peroxide temperature probably stayed around 65 degrees and pressure got up to a maximum of 500.

4.13 <u>Pre-retro Checklist</u>

Cernan — We did all of our cleaning up the night before.

Stafford — We did most of this the night before we went to sleep. We had some time and all the major items were squared away the night before. Early the next morning it was a very small work load.

Cernan — If they weren't stowed we had places to stow all the items that we were still using. Primarily the camera.

Cernan — The umbilical was the only thing. We took the umbilical down in my footwell which was no problem at all.

Stafford — We started aligning in plenty of time. We checked the primary scanner against the secondary scanner and again it was my qualitative evaluation that the secondary may have been a little bit tighter. It's a real subjective type situation. It was definitely better near sunrise and sunset and over cloudy areas and the deserts. We alined from 20 to 30 minutes, come over land mass, go to orbit rate, pitch down and take some pictures just to get the last bit of data. For the last Rev we continued to aline. Everytime we were in night time we turned out the lights and really got our retro pattern on the stars.

Cernan We had a dress rehearsal. We actually went to Orb Rate at that time and we had a dress rehearsal on our retrofire stars. The ATM was again checked that day. This time back on 4 alpha. Communications were good. OAMS operation was still good. We felt we had, when we left the adapter, three quarters of a molecule left in our Volkswagen tank. RCS operation, you checked.

Stafford RCS operation was just like previously described. We armed the rings over the States so they could observe us on telemetry as well as the onboard observations. I did a PULSE mode first and required about three or four pulses to start cracking the thrusters. After they did this each ring was just hard and crisp. The control modes and torques that were available were very much like the simulator. RCS just performed superbly

Cerman — Reentry stowage check list was completed. We went through all the preretro, the pre-preretro, the post retro check list as written. We didn't skip any items and didn't have any anomalies. Everything went real well. Generally the way we did this was I would read them even though most of these things were done. I would read them and Tom would verify them just to make sure that we had not overlooked any items. We had retrofire, we heard the countdown.

Stafford — We heard Neil counting down for us.

FCSD REP — I think you had a water gun problem about this time.

Stafford — Now this time it was still hard to actuate the actuating mechanism for the water gun but this wasn't bad as it was during that one period of time. But in this case you could tell the gun was charging down below and the amount of water was just dripping out. Each time it seemed like it got a little bit less. The amount of discharge per cycle went down a fourth or fifth of a normal cycle.

FCSD REP — Did it ever come back?

Stafford — No, it never did. We checked it and checked it.

5.0 RETROFIRE

Stafford: The checklist leading up to retrofire was completely adequate and we followed the checklist through each individual item. The RCS rings were armed over the States where telemetry was available to monitor them. The rings checked out well and the DCS load was resumed at this time. The DCS load was checked in the same manner we had practiced in simulations. We continued to aline the platform until approximately 3 minutes prior to retrofire and we went to Orb Rate. We took it down to the last because we didn't want the orbital torquing compensation - even though slightly off we were in a 87 by 145 - it was set up to 146. It wouldn't be off too much. We wanted to make sure that we had as small an error as possible on the platform. So we kept it there till approximately 3 minutes and then went to orbit rate.

5.1 <u>T_R-256 Checklist</u>

The T_R-256 checklist went on time.

5.2 <u>T_R-1:00 Checklist</u>

The T_R-1 checklist was exactly on time. The SEP-OAMS, SEP-ELECT, SEP-ADAPTER - the phenomena there is exactly as has been previously described on the flights. You can distinctly hear each event and there is definite thrust with SEP-ADAPTER. This time we were in range of Canton Island UHF and heard the CAP COM from Houston count us down and we fired on time. It

5.3 $\underline{T_{R-0}}$

was an automatic retrofire. The Pilot backed up the automatic with the manual. The misalinements were very little that I could ascertain. The second retro pitched me down some and to the right and I came back right away and I ended up with a little right in the IVI so I compensated for this with quite a bit of left on the third retro. This was similar to what we had on Gemini VI between each retro. Retro 1 and then 2. The IVI's were still in their counting cycle when the next retro would fire until we came between the third and fourth retro at that time the IVI's counted up stopped and had this big hesitation. I noticed Gene's hand was still on the retro button at that time.

Cernan: I never took my hand off the manual retrofire button until all four retro's had fired. It just stayed on there. We had normal retro's of 298 aft and 120 down. We got 296 aft and 125 down and 4 right. From these we figured the back up angles in reverse angles in case we lost contact with the ground.

5.4 Retropact Jettison
Stafford

The retro pack jettison was on time when the sequence light came on at T_R+45 seconds and with this the retro and docking bar jettison which produced a fairly noticeable pitch down torque. After retro jettison the retro power and retro jettison switch were put to safe. All the retro squibs were turned off, I opened the Boost Insert Control 1 and 2 and the Retro Sequence Control 1 and 2 circuit breakers. We used pulse mode ring A, rolled to the inverted position and at this time had a very nice moonlight horizon out there looking at the night airglow. At this time we turned off all the maneuver thruster circuit breakers, the attitude thruster circuit breakers, the OAMS circuit breakers, and all circuit breakers that were no longer functional for the spacecraft.

6.0 REENTRY

6.1 Reentry update

Cernan The reentry update was received. I received verbally the reentry retro update times from the ground for 400 K, bank, and reverse bank and the only thing that changed significantly was our bank angle went to 28 bank left, 38 bank right.

Stafford And the bank left 28 degrees corresponded well with the role commands. The roll command was just a little bit less then that.

6.2 Guidance

Stafford We hit 400,000 feet within one second of what the ground predicted.

Cernan We were given a down range needle deflection expected at 94 miles then we had about 120 miles when we saw guidance.

Stafford We held the bank angles for approximately 20 to 30 seconds until we were sure that the down range came into what the predicted was and all the reentry guidance looked good. From then on we followed the computer commands for maneuvering in this period of time. Immediately after the down range walked in the oscillation of the needles were not near what we experienced on the simulator. It was similar to what Neil Armstrong described on Gemini VIII. We had a little bit of left cross range, a very little, it was only about a degree and a half to two degrees deflection to the left. It started walking right in along with the down range. The down range came in very smooth with cross range. It followed the roll bug at this time as they both approach 0 we got the command to start rolling. We started to roll, completed two or three rolls, and at this time you could see the downward range start to move up a little bit. We anticipated this and started reducing the roll at the same time the roll bug told us to stop roll. We held just about full lift since the cross range came right down to 0. We held full lift for approximately 10 to 15 seconds I would estimate. Then it told us to roll and we were rolling and the needles were absolutely null. I got the reversal of the roll bug so everything was real good. I rolled and the reversal of the roll bug took us back to a roll in the opposite way. So it was from this, that it became obvious that the computer through the roll bug was sensing these smaller down range and cross range errors that were not manifest with the deflection of the needle since the needles were just about 0. The needle stayed 0 all the rest of the way in. We reversed several times, left and right. Near the last it gave us full lift, we pulled full lift and by this time we were out of the ionization sheath. I called 3 g, 2.5 g, 2 g, we were off the peg and as soon as the Pilot could hit the keyboard under the g field he did. He said we were right on top of the carrier at this time, I rolled 180 degrees to pull negative lift to prevent any over shoot.

Cernan This was a normal procedure in interrogating latitude and longitude to find out how our position was progressing and whether or not we were going past our target. This is a normal training procedure we used and it appeared to work out real well. I was able to punch the computer normally in the simulator many miles before target at point but in this case I hit it about 10 to 12 miles the first time I saw it. The first time I was able to punch we were 10 or 12 miles short and it was still going up but very slowly and that's the time we decided.

6.3 Impact Targeting Confidence

Stafford	We could tell by the rates which it was approaching we should be right on in latitude, and approaching it in longitude.
Cernan	We had a great deal of confidence at that point in our targeting and our impact point.
Stafford	Just as we approached reentry guidance at 400 K you start getting a very little aerodynamics and the vehicle builds up real slow oscillatory rates. I had my reference needles in Computer and Mix so when reentry guidance came I could see the big displacement. I used Mix so I could see the rates and damp these rates out in PULSE Mode to keep it fairly well damped down before we hit.
Cernan	We knew we were right on top of it and we gave a call.

6.4 Drogue Chute Deployment

Cernan	We hit drogue chute and the drogue came out. The oscillations that we had on the drogue

were not as much as what I experienced on Gemini VI. On Gemini VI most of the oscillation ceased at 35,000. The oscillation stayed approximately the same all the way down. We turned on the other ring of the RCS and then as we got down lower we turned the motor valves off to bleed the rings out.

6.5 Main Chute Deployment

Cernan — Then we hit the main chute deploy when we saw the barostat light which was real close to 10,600 feet. We had the proper altimeter setting. The main chute came out in a reefed condition, dereefed, it didn't flop at all just a beautiful dereefing. You could feel a good positive deceleration there. We slowed down at this time. On my yaw thruster I could see a large yellowish flame approximately 8 to 10 inches licking out. It came out and drifted back into the airflow. And Gene called the same thing back to me. He had two thrusters on fire.

Cernan — Two thrusters, they were yaw, the top yaw thrusters. Number 8 on my side.

Stafford — On my side it was number 3.

7.0 LANDING AND RECOVERY

Stafford

Number 3 was just burning. At this time I made a decision that I would not go to 2 point attitude, because of the bridle riding up above it. We stayed on single point attitude to about 4500 feet. At this time the fire went out in my thruster. We still had to go to 2 point attitude. We braced our ourselves and went to 2 point attitude. It was a good oscillation back and forth. I would estimate qualitative the accelerations that were generated with this one sequence to be approximately 8/10ths of what we had on Gemini VI. We were all squared away. Our shoulder harness was still locked, our seat belts tight and I told Gene to stand by for impact and we really hit.

7.1 Impact

Stafford

It was by far the worse impact I have ever experienced in my life. We went way under the water. I popped up, my head was jerked down and I looked down at the foot well. A sheet of water came in and splashed on the bottom of the foot well up into the forward part of the foot well. Then it rolled back down as the

	spacecraft trimed a little nose up in respect to the floor of the bulkhead. The bulkhead - you know, the floor. Immediately Gene got the repress valve. The sheet of water covered all my floor. It was a sheet of water that hit the forward front of the small pressure bulkhead and went up there and splashed back down in the ECS well.
FCSD Rep	Would you say about a quart?
Stafford	It was a pretty noticeable amount of water that came in. It was a flat sheet of water that came in and hit the forward bulkhead, went up and came back down.
Cernan	I only noticed a few drops of water on my side.
Stafford	After the water went back down, I never saw any more.
FCSD Rep	Which way was the spacecraft pitched? Was it pitched down to the left at this time?
Stafford	I don't think we had much roll. I think we hit just flat and straight on in. That's the way it seemed to me. We didn't roll very much. I couldn't tell whether it was for or aft but it felt like from our viewpoint, the impact came straight through bottom position up.

BANG. Now after the impact we did pitch down a little bit. Then after that we pitched up. The sheet of water came over in my foot well, and came up and hit the front wall, then right away ran back down as we trimmed up in the position where the foot well was sloping slightly up.

FCSD Rep — Did you feel any change in your flow to your suit at this time or later?

Cernan — No, this other comes under postlanding spacecraft status 7-4.

7.2 <u>Communications</u>

Cernan — UHF, all the way down was excellent. We knew that we were right in the vicinity of the ship. The ship knew what our estimated miss-distance was. They had us on radar; they told us that we had the helicopters nearby and the communications were excellent. We never extended the HF antenna, because the frogmen were all around us and, at 3000 feet, the ship said that they had us insight, dead ahead a couple of miles. We looked out the window and there was a helicopter looking us right in the face all of the way down and as soon as we hit the water, there were frogmen all around. I could see no use in extending the HF antenna at that time.

7.3 Postlanding Spacecraft Status

Cernan   We were on O_2 high rate, just as we had planned. The first time when Tom said "we had water", I turned the repress valve on and the cabin immediately went up to almost four psi before I got it shut off. This satisfied us that we were going to stop the water. We went up to 4 psi and shut off and it stayed there for awhile. We had no RCS fumes, none whatsoever in the spacecraft. The main chute Tom jettisoned....

Stafford   As soon as we recovered from the impact, it was recovered. We knew on our way down that we were in close proximity to the carrier. As soon as we hit the water and came back up, not more than a few seconds later, there was a frogman dropping down in front of my window. On most of the reentry all the whiteish-gray layer on the inside of the outer pane turned into water droplets and those became crystalline form with a elongated hexagonal axis shape with the major axis alined approximately vertical and these crystalline forms are still on the spacecraft on the inside of the outer pane and the outside of the middle pane. And also the outside had this regular curling that we experienced on Gemini VI and then when the water hit it, it was a real dirty mess outside. On our way down on Post Retrofire, we turned off all circuit breakers we didn't need and got the rest of them off somewhere on our way down. After we hit the water, we left the squib batteries and the main battery on, and the suit fan one and two and the suit fan circuit breakers were left on and we were on O_2 high rate. So that was our Electrical Power configuration. Oxygen; number 1 bottle, last I saw it, was down somewhere around 1,000 psia and the right hand bottle was up around 4 to 5,000. Hatches; we put our splash curtains on, and the Command Pilot opened his hatch first and we opened it just a skosh before we had the cabin depressurized down to ambient.

7.4 Comfort

Cernan — It got a little bit warm, so we removed our helmets immediately, utilized where we could the light-weight headset for communications.

I was comfortable. I couldn't have been uncomfortable at that point anyway. The sea condition was moderate.

Stafford — Sea condition was moderate. There were large swells, but very little waves. There were no real waves out there. They were just swells.

Cernan — No sea sickness, no nausea, or nothing at all. No water came into the spacecraft even if the splash curtains had been down, no water would have come over into the spacecraft.

Stafford — I looked down in the ECS well and it was dark down there. Both of us continued to look for water but couldn't see any. Of course, with the trim attitude, all the water would run down into the lower aft section of the spacecraft and it was dark there and we couldn't see anything. We were monitoring all the time to check if any water came in.

7.5 Recovery Team

Stafford — This was after the collar was all on. We had communications with the headset for awhile but then we lost it. We were talking to one of the frogmen but he didn't say anything. The next thing I noticed the frogmen had the "T" handle, climbing up on my hatch to open it. So, we thought we were all vented to ambient but just in case I went ahead and started cracking the hatch and held on to the nylon tie-down lanyard as I was cracking it. When I got it cracked, there was still a small psi and bang!, the hatch just flew to the full open position and jerked out of my hand and it hit the frogman in the head. He suffered a slight cut on his forehead.

7.6 <u>Crew Egress</u>

Cernan — The crew did not egress until the spacecraft was on the carrier. We closed our hatches while they brought us up on number 3 elevator and then we egressed.

7.7 <u>Survival Gear</u>

Cernan — Survival gear was not used.

8.0 SYSTEM OPERATIONS

Stafford — The platform performed superbly throughout the entire mission. Alinement was made both with primary and secondary scanners and I think that I previously mentioned that the secondary scanners performed as outlined in that they should have less tendency to break lock at sunrise and sunset and over clouds.

8.1 Platform

Stafford — We did use horizon scan mode some of the time and this was borne out, using horizon scan primary and secondary scanners. CAGE,SEF,BEF, ORB RATE,and FREE Modes all worked very well. The FDAI and the window markings were good.

Cernan — The only anomaly in the FDAI's was the time when we kicked off the scanner circuit breakers.

Stafford — There was one other time associated with the NSR maneuver for the first rendezvous. At one time the needles were non-directional even though we were 0,0,0 we cycled back to rendezvous and came back and then they came directional.

Cernan — This was the Comp and Attitude...

Stafford — Comp and Attitude Reference Mode...

Cernan — We conducted the Accelerometer Bias over Carnarvon on our first pass and then we did another over Australia later on.

Stafford — And we were updated - and lets say the update did a real good job on the Accelerometer Bias.

8.2 OAMS

Stafford — On the pad the static fire on our second launch attempt was the first static fire. We did have to make two complete checks around. You could tell that the gas in the line was hammering against the valve, particularly on the yaw left thruster. We had to hit that and also when we finally did launch we went around and had to come back and hit the yaw left and it looked real good. And also, we stroked it real good the second time.

Cernan — Three times through the boost phase all systems were monitored; all OAMS systems pressures and temperatures. OAMS Propellent remaining was checked after each burn and after each rendezvous whichever was more convenient. Selector controls and switches all worked normal, no problems. Maneuver Controllers on both sides worked normal. We utilized both Maneuver Controllers because each one of us did some burns. I don't believe there were any inflight malfunctions were there, Tom?

Stafford — The Attitude Control Modes were just exactly as in the specifications for the Gemini Spacecraft. They just performed perfect.

Cernan — Heaters seemed to be working fine. We never did get a RCS heater light but we turned on our RCS heater the first night when we went to sleep.

Stafford — And we had them on ever night when we slept.

Cernan — And the first night we went to sleep we had no RCS light but we put the heaters on and left them on.

8.3 <u>RCS</u>

Stafford — On the pre-retro checklist the RCS checks were performed over the states where we had telemetry monitoring and were nominal.

Cernan — We monitored the systems, RCS ring A and B pressure, all through the flight, just as we checked all the other systems, and also during reentry. We were primarily reading RCS ring A. We were actually checking them both all the way down where we could. Selector Controls and Switches all worked well. We had no inflight malfunctions. Control modes, heaters, as we just discussed RCS heaters were turned on when we went to sleep and were left on. We never got a RCS heater light. You could see the thruster flumes. Tom, do you want to describe how you bled the system down. It was normal operation.

Stafford — We closed the motor valves. Because of the oscillations we waited a little bit longer on the chute than we practiced in the simulator. When we shut the motor valves, they stopped firing within about 5 or 6 seconds. There were no fumes; we just had the yellow flames coming out of the yaw thrusters.

Cernan — We had no fumes. You want to talk about suits?

8.4 ECS

Stafford — Typical for the G-4-C suits that we had. Mobility is as much or can be expected for that suit. Now inside the cockpit I had excellent mobility when pressurized. It was hard to operate the camera because the close proximity up by your helmet with the camera. The pressure held about 3.6 throughout the EVA operations. Temperature was very good, the humidity was low, I never saw the CO_2 gage move off the peg.

Cernan — Never.

Stafford — It never moved off the zero position. Comfort was adequate. The controls were all right. The O_2 demand regulator functioned normal. On the umbilical; you want to comment on that, Gene?

Cernan — Okay, the suit on the Pilot, the mobility was good. It was a tight-fitting suit. It was built that way because primary concern was operating pressurized. In a nonpressurized condition it was a snug-fitting suit but the mobility in the spacecraft was as good as can be expected. I had no pressure points - the suit was actually fairly comfortable. It was as comfortable as suits go. The temperature was a little warm for powered up conditions during the day because we were doing a lot of work, a lot of moving about. It's very easy whenyou're unstowing and stowing gear to generate a heat load very quickly. In those conditions the temperature does go up. Humidity seemed to be okay; no CO_2 problems. Comfort was good with the exception of the neckring. All the bookwork I had to do, the writing, that neckring bothered me. My chin was always rubbing on the neckring and it was a source of discomfort. I tried to find someway to get rid of it or put it out of the way, or keep it under my chin.

~~Cernan~~ It was always in the way and it was always there. In about three days it became a case of becoming accustomed to it. The O_2 demand regulator functioned properly. The umbilical worked fine. No problem with the Y-connectors.
Electrical jumpers worked fine, no problems. Stand up hoses; we put on the Spacecraft ECS hoses but never utilized them. Thermal gloves fit extremely tight but they were built that way They were fine in the pressurized condition.

Stafford The interconnects worked good. I taped one locking tab on each interconnect.

Cernan The umbilical bag was good. The wrist mirror was carried and utilized to the extent that it was part of my EVA gear. It was with me outside but I never really used it or relied upon it for anything. The ELSS restraint system was good. I would prefer to have it ride a little bit lower than I had it. The electrical extension worked beautifully. As a matter of fact the routing of the spacecraft electrical cable with this electrical extension onto the umbilical was smooth and neat. It was routed next to the seat. I had Velcro put under the Volkswagon pouch and I fed it under the Volkswagon pouch which held it down. It went right up out the top of the hatch and was the exact proper length. It was not kinked, it was smooth and never got in the way. It was one of the neatest things of the whole umbilical operation. The hatch closing device worked properly. Spacecraft tether hook on the umbilical, I assume this is what we are talking about, was fine. EV visor, we discussed. The debris cutter was not used. If we are going to carry the debris cutter in that area, we are going to have to find a one hand operation of velcroing them around that handrail extension.

Stafford — The cabin pressure went to nearly 6 psi on boost as you would expect. It then came down to 5 psi and held this until the evening before retrofire.

Cernan — The last night before retrofire. We woke up and the ground informed us that it had bled down to about 4.7. We looked at it and we agreed with them. They didn't say anything further and we didn't either so we pumped it up with the repress valve and then of course the next half hour we watched it bleed down again to 4.7. So we pumped it up again. We closed the water seal and it held. About a half hour later we opened the water seal to see if the regulator was actually leaking and it continued to hold...

Stafford — It held 5 psi.

Cernan — We closed the water seal and that stopped the decay of pressure and then when we opened the water seal the decay of pressure never started again. Temperature in the cabin varied with the power up and power down condition and then it got very comfortable at night and we went to one suit fan and it even got a little bit cool sometimes at night but we were able to control it with suit flow.

Stafford — In the daytime we always had the primary and secondary A pumps on. 80 percent of the time we used suit fan 1 and 2 in the day. At night-time we went down to suit fan number 1 and used both B pumps. Most of the times we cracked our suit flow down to a quarter or nearly full off, because of the temperature.

Cernan — There was no visual moisture or humidity, although anything that we did get wet never did dry out. No CO_2 . I was comfortable day and night. Cabin fans we talked about. Primarily during the day operation 1 and 2 - at nights 1. The cabin pressure relief valve we know worked because when we were on the ELSS flow during EVA PREP it was venting on about 5.8 or 5.9 about 30 second intervals. Cabin vent valves worked properly during EVA and recovery. Cabin repress valve worked fine.

Stafford — Cabin inlet valve was all right.

Cernan — Cabin Air recirculation valve!

Stafford — Nominal.

Cernan — Primary O_2 system monitoring!

Stafford — Worked real good. I watched it very closely during EVA since the Pilot was using a lot of high rate. You could see the total quantity drop all the time. I kept the ground informed of this and at one time I wanted to know, because the rate of drop, if they wanted to open the cross feed with respect to the RCS O_2 and they said, 'No, we can monitor it all the way through.'

Cernan — Secondary O_2. Both bottles were right up there about 5600 until during reentry. ELSS controls, connections, systems operation, systems monitoring operation, restraint straps, all worked as advertised and as trained with, both in chamber and in other ground systems.

Stafford — On the restraint straps, again - just to re-emphasize the points; the ELSS did float up and the ball was required to reposition the ELSS.

Cernan — I did actually reposition it standing in the seat one time and it still tended to get too high on me. AMU controls, connections; I think I've covered all this during EVA. Basically there were no anomalies in the AMU and it would have been "GO". Communications were not as good as hoped for at least not from the Adapter but they were "GO". We could have accomplished everything on the AMU based upon the configuration that we had checked out. All systems, gas systems, mechanical systems, at th't point were go. We came thru the Boost Phase just as expected without any problems. The twenty-five foot umbilical was good. Connections were easy. Dynamics of the umbilical were overshadowed by other dynamics of EVA activity.

[redacted]

Stafford	I think we could say that the dynamics of the umbilical were very...
Cernan	Negligible...
Stafford	small and negligible.
Cernan	Stowage. What about getting out?
Stafford	Very little effort was required in getting the umbilical out. It came out approximately 6 inches than seemed to stick. I was still facing forward in my seat. I reached around and grabbed one hand on the lanyard and with the other hand I kept working with it with and in just a small amount of time it came out very easily.
Cernan	And of course it was hard to stow so we didn't. Collant and radiator operation and evaporator operation and coolant loop operation all seemed to work normal. We had no failures and no problems. The water management...
Stafford	The panel accesibility as previously pointed out is rather poor. It's probably the only place you can put it in the Gemini spacecraft. It did require a little bit of effort when we had to go through the urine cycle. I used a swizzle stick to start with and then after that

[redacted]

I was able to take my right hand and reach back under and feel the switch and go to the Preheat and the dump cycle on the electric switch with my fingers. Toward the end I was using my fingers to rotate the waste valve to the overboard dump position. Now, it would go to the overboard dump position very easily but after we had a urine dump it would seem to freeze up there for a while and it would take a lot of torque applied to it to get it back. And if you would wait a little while it would come back very easily.

Cernan — It was difficult for the Pilot to operate that panel because of the holster for the water gun and it was difficult to see for another reason. The Command Pilot did most of the water management system operation.

8.5 Communications

Cernan	Interphone was good UHF performance I thought was excellent all the way through, both UHF 1 and UHF 2. I thought voice procedures were good. HF, we never checked out.
Stafford	Voice tape recorder worked as prescribed. It is about impossible to change it in a pressurized condition; so we had a new tape at the start of the EVA maneuver so we could cover all the major important items in the EVA sequence.
Cernan	Digital Command System worked very fine except it at T - 3 and 1:45 and 2:25 during the launch we got no updates. I think everything worked there. Communications and Controls switches - Sleep Configuration.
Stafford	Oh! In the Communications Control Switches as has been previously experienced the rubber grommet that is to prevent moisture from getting into the VCC was torn after one day's operation, on my side.
Cernan	Mine was good.
Stafford	The Pilot's side was intact all the time and mine tore after one day's operation.

Cernan Sleep configuration was in the interphone so we could monitor the UHF. The first and third night's the Pilot had the silent switch on and the second night the Command Pilot had the silent switch on. Beacon control, TM controls, no problem. The only problem in here was that we lost that onboard tape capability.

8.6 Electrical

Cernan Fuel cell operation was beautiful. You could watch suit fans go from No. 1 to No. 2 on each of the 6 stacks. You could see it during almost every other current changeover, that was significant, that you needed to see it on. I felt that monitoring the 6 stacks gave me a great deal of confidence in the performance of each stack of the fuel cell. They just performed just beautifully. I was very satisfied to have had 6 stack currents available to me.

Stafford If you have fuel cells that perform the way that they did on Gemini IX you do not need the main BUS ampmeters.

Cernan I think it is even more important to have the stack current ampmeter readings when you get a

[redacted]

malfunction. Because then you can identify exactly where that malfunction exists. For normal operations where the cells are performing as they should you can see, in almost all instances, the changes in current drainage when you power up or power down. We had one main battery that was sort of bad. No. 2 was around 21 volts - No. 1 was good, No. 3 and 4 were moderately good. Squib batteries were on during the whole flight. Based upon our hydrogen quantity, we felt that we were fat on electrical power. We had no problems at all in total electrical power.

[redacted]

8.7 Onboard Computer

Cernan — I think we covered most of that during the rendezvous and during the orbit phases. All the Computer Modes, Pre-launch, Ascent, Catch-Up, Rendezvous, Reentry, all worked fine. The ATM tape memory worked beautifully.

8.8 Radar

Stafford — The warmup time we used approximately 3 min. Every time as soon as we would go to the on position within 5 seconds we had a green light for lock on and good valid lock on. Of course, the needles would waver but range was there, cold and hard.

Cernan — When we alined, however, we were unable to read out range or range rate although the green lock on light remained on. But you could not readout Address 36 or 35 - 35 obviously, you cannot readout 36 or 69 for that matter.

8.9 Crew Station

Stafford — On landing...

Cernan — On landing, cracked.. Swizzle stick worked fine. The fact is it's single point failure during EVA.

Stafford — This is why we had a lanyard hooked to it because it would be impossible for me to arm the experiment BUS and also deploy the EVA bars and the dock light or the EVA light.

Cernan — The only anomaly in lighting was the left hand aux recepticle extension cord. That was only the one part of the cord that went to the aux light and it worked part of the time and part of the time it did not. It ended up on the Pilot's side and it appeared to work a majority of the time on that side. It could be made to flicker on and off with manipulation of that part of the cord.

Stafford — Due to our variable flight plans we did use the flight plan book to some extent. We used segments of the flight plan book and the data cards I thought were superb. I don't think that any changes are needed except for a specific mission.

Cernan — Going through this whole list of onboard data, I think we put enough time in it. I say we, but there was a lot of people who put enough time in it and we got it in the format that we desired. We got the information in there that was required, we got the Velcro on the rendezvous book in places we thought that it was needed. I don't have one note of discrepancy report at all on any of these books. I think they all worked fine and I think that the way we recapped the sequential checklist and put double rings in them just worked excellently. I don't have anything but good news to say about all of our on-board data. Stowage - no problems with unstowing. It's the stowage that's really okay.

Stafford One reason our stowage went so smooth is the fact that we practiced it so many times. We did have a complicated overall stowage to perform. We had an unstowage list that went right down item by item and so the cockpit was always clean, and in good shape.

Cernan Real-time stowing and unstowing of gear while you're in flight is a major effort. It's not necessarily a major problem all the time but it's a major effort so you want to make sure that this is held to a minimum. I mean stowage and unstowage in the aft boxes. Once you restow and unstow things you want to make them somewhat permanent back there because, as I mentioned before, it does generate a heat load and it's a great deal of work to get back in there and stow and unstow things properly in zero g. There's probably no sense in going down these things - harnesses, life vests, everything else was stowed just as we had planned to stow it on our post rendezvous - pre-rendezvous checklist. We went right through the rest of our checklist pretty much as we had planned. Having inner places to stow things helped a great deal. Want to compare the Mauer and Hasselblad?

FCSD-REP How about your life vests! Did you have any problem getting those on?

Cernan No problem at all getting them on. The markings were great - left C meant left hand side for Cernan, and that was great, and neither one of us had any problems.

Stafford And we also had which strap went over first, one to one, two to two. It's just a small item but it certainly helps you.

FCSD - REP Do you want to compare the Hasselblad and Mauer?

Stafford Let's have a separate section on cameras.

Cernan Optical sight voltage regulator. You didn't have to have that...

Stafford No, I did not need the voltage regulator.

Cernan Right hand transparent reticle. I didn't use it. Didn't need it. I don't think it's required. Camera alinement marks. Well, we're going to talk about cameras. Equipment Color Coding. Equipment color coding, although a small item is very important in real life up there in the spacecraft and it helps a great deal.

8.10 <u>Adapter</u> The bassinet hung up so one handle bar did not come out and the umbilical guard on the handle bar did not come out, but that was broken loose. It was discussed in EVA.

The lighting. Facing the AMU, the lighting on the right side was on. The light on the left side was out. It was not broken, it just did not light. I had one good pen light, one bad pen light. I feel that the lighting at night is adequate, it's dark but it certainly is adequate back there to do the job you want to do.

Handle bars are adequate. The foot bar and stirrups are inadequate. We need to take a good look at some more positive method to restrain yourself in the desired position because I feel that 50 percent of your work load is trying to maintain a position. The other 50 percent of the work load is trying to do a job. If we could eliminate the first 50 we'd be way ahead. So we have to find some way of developing a foot hold to maintain your position in the adapter. The mirrors were still stowed and were not dirty and were adequate.

The tie downs. I'm not sure what tie downs. The mirror tie downs that held the mirrors down. There were no problems there.

The umbilical guide that goes around the adapter separation plane was good. It worked fine. The umbilical guard that's on the hand rail is inadequate. We need more compression force to hold the umbilical in there and keep it from slipping out.

Separation plane was clean as a whistle. It was jagged edges as expected but they were - there was no loose debris hanging from it at all.

8.11 Tether

The tether. We need big rings and big hooks. Stowage was good.

8.12 Spacecraft Exterior

Dynamics not evaluated. Hatch operation was talked about. It was still in the middle ranges.

Hatch umbilical guide we did not have. I don't feel we need one. The hand rails are very valuable on the top of the spacecraft. The Velcro could help but again, only on the top of the spacecraft or at a position that your body is free to float up because you cannot put any torques with your wrists or hands when you're using Velcro pads.

Tie downs, I'm not sure what we're talking about.

Windows - are you going to discuss these separately, Tom?

Stafford — Right.

Cernan — Docking bar was deployed and worked normally. Docking bar mirror we talked about and was excellent. EVA camera mount, it was difficult to get the bracket in the mount. The nose ring was not utilized but was there and could be utilized very easily. The UHF antenna was used as a hand hold.

8.13 AMU Stowage — AMU stowage was good.

Control and Operation connections. We didn't get to the operations but everything else as far as checked out was GO and good, acceptable.

8.14 Biomedical

Stafford — Because of the operational research missions that we are in now, the only communications that should be associated with the crew status report is the fact that you have your oral temperature in once a day. With respect to how much water we drank; due to the vast medical support team on the ground, all we insisted on giving was the total water gun count and I'm sure that they are able to compute the amount of water that was drunk from the last one. We split the water about 50-50 and as far as the meals consumed - knowing what meal - I think your tastes vary from day to day and so we used parts of various meals. We used a lot of hydratables, rehydratables. Just the number of meals you have is all that is needed. It should be short and to the point.

Cernan: As far as meals are concerned, when you are in the process of rendezvousing, you don't have the luxury of taking out an hour and sitting down and eating dinner. You catch it as you can. You eat a brownie, you drink some juice, you do some work, you grab another bacon cube, and it is difficult to know whether you grabbed your buddy's bacon cube or yours or how much juice you drank and which meal it came out of. It's just a case of getting nourishment when and how you can. This is a very realistic operational aspect of eating. It's the only way it can be done. Very seldom, maybe before we went powered down - and at night before we went to bed, did we actually just sit down and talk a little bit and chew on some food and do nothing else.

Stafford: I thought that the pre-flight physical was getting down to a reasonable level. We had this outline with the medical group on exactly the amount of time that is going to be allocated to them on the carrier. The total physical including the tilt required approximately one hour and 30 to 40 minutes and this is certainly adequate for the physical afterwards. It was performed in a very expeditious manner and also, it was in a very thorough manner. People on-board the carrier should be complimented for the job that they did. It is obvious to us that they had practiced a lot to get a time sequence that wouldn't cut into the crew's time. With respect to one biomedical experiment - the M-5 - it is our analysis that the amount of time and effort involved in logging and stowing and restowing all the sample bags is equal to the total effort involved in at least one and one-half rendezvouses.

Stafford The sleep periods that were scheduled were adequate, however, during the first one, both of us were very fatigued and had a difficult time in sleeping. On the subsequent sleep periods we experienced no difficulty in sleeping.

Cernan We had a real-time sleep period scheduled after the third rendezvous. A period of about two hours which was given as an added period and we probably slept more or rested more in those two hours than we did in the first night's eight hour sleep period. So I think sleep periods' scheduling is fine but it's still going to be a function of how tired you are and how ready you are to sleep.

Cernan

We powered down and the night before we went to bed, we actually did sit down and talk a little bit and chewed on some food and did nothing else. With respect to the BIO MED, I thought that the pre-flight physical was getting down to a reasonable level. We had this outlined with the medical group exactly as to the amount of time that was going to be allocated to them on the carrier. The total physical, including the tilt, required approximately one hour and 30 to 40 minutes and this is certainly adequate for the physical afterwards. It was performed in a very expeditious manner and also a very thorough manner. The people onboard the carrier should be complemented for the job that they did. It is obvious to us that they had practiced a lot to get the time sequence, so as to bother the crew minimally. The M-5 experiment; it was our analysis that the amount of time and effort involved in logging and stowing and restowing and restowing all the sample bags was equal to the total effort involved in at least one and one half rendezvous. The scheduled sleep periods were adequate, however during the first sleep period both of us were very fatigued and had a difficult time sleeping. On the subsequent sleep periods, we experienced no difficulty in sleeping. We had a real time sleep period scheduled after the third rendezvous, a period of about two hours. It was given as an added rest period and we probably rested more during those two hours than we did on the first night's eight hour sleep period. I think sleep periods scheduling is fine, but it's still going to be a function of how tired you are or how ready you are to go to sleep.

Stafford: Even though we had aluminum covers on the windows, a little light did leak in. You could be sound asleep and when the spacecraft slowly drifted into the sun, light would leak in and light up the spacecraft a small amount. Just enough to break your sleep period. So, we recommend that they extend the sides of the aluminum covers and put a black felt material on the edge, so that no light will leak in.

Cernan

We had Velcro all around our window, but we needed a piece of felt to filter in between the roughness of the Velcro to keep light from leaking in.

9.0 VISUAL SIGHTINGS

9.1 Countdown

Cernan — Saw a couple of mud daubers during launch attempt number 2.

9.2 Powered Flight

Stafford — I was watching the spacecraft gages, so I didn't see out at all. At BECO, we did experience the orange flame with the black ring. While I had my hand in front of my face to block out the sun, it appeared to me, that the staging sequence and the associated fire-ball or orange sheet of flame was less than what I had seen on Spacecraft VI.

Cernan — From the Pilot's window, the staging sequence produced a dirty orange sheet of flame on the right side of the window. It was not a big envelope which we flew through. It was just a sheet that projected along the side of the spacecraft and out in front, maybe 10 or 12 feet.

It was a dirty orange flame impregnated with smoke or with black particles, which I would say was definitely smoke. It was not a big cloud of flame that we flew through.

Stafford — Engine 2 ignition on the staging sequence has pretty well been covered. Nothing new from what we've seen before. The outer jettisonable window covers did pick up residue on the boosted flight. This was obvious because you could see a smoked layer on the outside of it prior to jettisoning the window. After jettisoning the cover, the outside window pane also had this grayish-black residue on it, a thin film. It appeared to be more intense near the outer edge of the window. It was nearly clear in the center of the window.

FCSD REP — Do you think it was on the outside or inside of the window?

Stafford — That was the outside of the outer pane, definitely. If you looked at it obliquely, you could see the thickness. Towards the end of the first day, I noticed a slight silverish-gray matter developing on the inside of the outer pane. As the flight progressed, this grew from a very thin film to a nearly white opaque film. The intensity of the film was such that prior to retrofire, when we went through the night phases or orbit, a lot of the minor stars would be blanked out. Looking straight ahead, I could not see anything less than a third magnitude star through the center part of the window. Near the outer edges, I could see more. The big mass was in the center and it started out as a light thin gray film, just like a light fog. It kept continuing to increase until it was nearly white opaque. On reentry, this turned into waterlike droplets, then crystalized. This material is still on the inside of the outer window and it also appears to be on the outside of the middle window. From the various photographs, you can see this material that has built up.

9.3 Orbital Flight

No observations were made of other objects in flight, other than what originated from the spacecraft itself, such as pieces of fiber glass and little frost particles that floated off. We did not see any satellites. Regarding the ATDA. We saw first the acquisition lights flashing right after we went into darkness on the first rendezvous, at TPI plus approximately five minutes. This was 20 miles. We'd see it intermittently as the ATDA would rotate through various angles and blank out the flashing lights. When we had closed to approximately four miles, you could ascertain color; usually a red color from the red lights on the ATDA. Station keeping at night was very easily done and all the amber, green and red lights were very easily seen. You could see the ATDA plume, from the RCS rings, firing during the day time and I estimate that the plumes extended out four feet or possibly further. It was a long thin plume. Going out from the plume, you could see drops of N_2O_4, yellowish drops of N_2O_4 and some of these impinged upon the spacecraft. The first time we observed the ATDA, in reflected sunlight, was on the first rendezvous at approximately 50 miles and it was between a fifth and a sixth magnitude star. It grew in intensity all the way until it crossed the sun line into darkness. Just prior to the sun line and darkness, it was near the magnitude of a minus 2 starlike Sirius. It was not as bright as Spacecraft VII, as I'd observed on the Gemini VII and VI mission. During the passive rendezvous, we inverted and we were behind it, coming up towards it. We saw it immediately at about nine miles. It was far brighter than Venus. It was about equal to Venus or a little brighter. During the daytime, it increased in intensity. In the reflected sunlight, we could actually see the cone and the body at one mile. The area between the cone was open and it appeared as a thin black line at one mile. There was no difficulty in ascertaining the major axis of the body in degrees. Even though it was slowly translating, you could ascertain distance by use of the reticle. The moonlight reflected the whole body very well. It gave us a great cue, even though it blanked out stars. It gave us a great cue as far as the rate of closure on the ATDA. On the rendezvous from above, just prior to sunrise, the moon light reflecting on the ATDA gave it a brilliant whitish-blue spot, crossing to dark brown. I'd estimate it was four to five times the diameter of Venus. This faded out in sunrise. It became smaller in diameter and became a redish object and finally decreased in diameter to absolutely nothing when we got in sunlight.

Cernan — I had no unusual visual sighting while I was EVA.

Stafford — Geographical visual sightings. Nothing unusual was noted, we covered the same latitudes as on the previous mission. I saw nothing of an unusual nature. There was far less cloud coverage than on Gemini VI, even though it was still considerably cloudy over the earth that we covered. Stars during the rendezvous phase. The constellation Antaries and Scorpio were the prime celestial fixes we had during the rendezvous phase. However, the final inertial angle that we obtained put the ATDA very near the moon and it held near the moon throughout the terminal phase. It washed out all the stars except one that was approximately four to five degrees away from the ATDA. So, the stars did not really help us during the final and terminal phase. The other two rendezvous were done one in daytime from below and the other in daytime, from above and the stars did not help us in these cases. There was tremendous cloud coverage, but it wasn't as much as on Gemini VI. One thing different between Gemini VI and Gemini VII was the night airglow. On Gemini VI, the moon did not have the same magnitude that it had on Gemini IX. On Gemini VI, the night horizon was a definite whitish yellow band and it was very hard to see the airglow above it. On this flight, you could see the horizon down below. It was less in intensity as far as the whitish yellow portion. Above it in the airglow, approximately three degrees, the airglow was a dirty red or grayish color.

Cernan: It was just a gray line.

Stafford: It was kind of a dirty color. To me, it was a kind of a redish gray color and then a definite ridge above that.

Cernan — You could see stars at night between this line and the horizon. It was an extra horizon line. It was at a greater distance from the horizon, then the day airglow. When we crossed the continent of South America and went from land to water or water to land, with a few scattered clouds, you couldn't tell when you passed from water to land or land to water, with one exception: you could see the spinal trends of the rivers over the land masses. They were gray or bright white, like veins.

Stafford — This phenomenon occurred after we passed the Andes Mts.,Paraguay, Argentina and Uruguay. This phenomena can be associated with all the haze layer above the tropical rain forests. You could tell that there was considerable haze above the ground down below. It was afternoon near sunset, it was impossible to tell whether that was ocean or land mass.

Cernan — The land mass itself was dark like the ocean. Out of this darkness, you could see the rivers that were redish and bright. They were very distinguishable.

Stafford — You couldn't tell whether it was ocean or land. It was hazy and it was towards sunset. For awhile, we thought we were out in the ocean. We looked down and saw a river. It was the color contrast that made you aware that you were still over a land mass.

Cernan — You could see the attitude thrusters fire at night.

Stafford — At night. It was just like little lightning flashes along side the spacecraft.

9.4 <u>Reentry</u>

Cernan — We could not see the adapter during reentry. We could not see the retropack jettison, but we did see something burning up during reentry, which was probably the retropack.

Stafford — The docking bar jettison was the same as I'd experienced on VI. It's like a Roman candle near the end of burnout where it fizzed with a couple of sparks on the nose. Just a regular device firing at night. Right after 400K and ionization, we could see little red dots spread out into a very big thin sheet all the way around the spacecraft. It suddenly increased in intensity and you could see definite sheets of flame coming from the heat shield around over the spacecraft. We would trim it at an angle and the spacecraft would yaw or pitch off and the whole ionization layer and the fire would go away from the windows of the spacecraft. You would oscillate back into it, back and forth. When you were in these positions you could see the ground with very little fire over the windows. When you'd roll the other way and the fire would completely cover the windows. I think this could be borne out from the films that we obtained on reentry.

Cernan They explain visual reentry better than we could.

Stafford The spacecraft oscillations were in the dead band, plus or minus four degrees per second. We had very little thruster firing except when we were accelerating or stopping roll. We passed through the contrail level again at high altitude and we could see this condensation off the nose. You could see the drogue come out and then dereef. We could see the drogue oscillating back and forth, pass through several cloud layers. At R & R can separation, we could see pieces of the R & R section being blown away and the drogue pulling the R & R can out. The main chute came out in a reefed condition, open very symmetrically, no waving of the chute at all. Just very symmetrically.

FCSD REP — Did you notice the cabin air door blow when you hit the drogue?

Stafford — No. It left, I did not see it. Nobody's seen that yet.

10.0 EXPERIMENTS

10.1 Particle Collection Device (S-12)

Cernan: We had the understanding that S-12 could be stowed on the center line bracket and still have the capability to open that bracket so that we could take out the centerline camera box. This is not true. You can not open the bracket with S-12 stowed on it. We had to leave S-12 in a footwell pouch til pre-retro stowage. When we got all cameras back that we wanted to put back and secured the center line stowage box, then we stowed S-12. As it turned out, this was not a problem, but I highly recommend that anything else we plan on retrieving and stowing on that center line bracket, that if at all possible, we have the capability of stowing it and still have capability of opening and closing the bracket for centerline camera box access.

Stafford: The part of the S-12 device that interferred was the connector on the end of it.

Cernan: Yes, the plug.

Stafford: It impinged upon the cabin center light.

10.2 Bioassays of Body Fluids (M-5)

The work associated with M-5 can be detailed as equal to nearly one and a half rendezvous. With the extra container urine sample bag, the taking of the sample, the labeling of the sample, and particularly, the stowage of these urine sample bags and the restowage of the urine sample bags everytime we had any stowage oeientation in the cockpit, particularly for EVA, presented a tremendous work effort. Again, we'd equate it to the work (the total involved for M-5 on this mission), as equal to about one and a half rendezvous. Associated with this, was all the blood withdrawal prior to the mission and after the mission. The amount of blood obtained was considered excessive and also the physiological pain associated with the withdrawing of blood, makes the total experiment questionable as far as the impact upon the crew's comfort and efficiency prior to the flight.

FCSD REP — Was the equipment adequately explained to you in briefing?

Cernan

We understood the equipment, but it made the natural requirement for living in space and urination which is all ready somewhat of a project in its own right, a project multiplied by about a magnitude of five in terms of time required, of manipulations and operations for the whole procedure. Anytime you increase activity in space in a small spacecraft, such as Gemini, you increase work loads. You increase heat loads and you increase stowage problems. We were confronted with everyone of these problems as a result of M-5. It made what should have been a simple task an inappropriately complex task.

11.0 PREMISSION PLANNING

11.1 Mission plan, (trajectories)

Stafford — I think very little improvement could be made. The Flight Operations Division presented us with the mission trajectories and in adequate time for obtaining rendezvous charts for this training.

11.2 Flight plan

Stafford — We held the line as far as perturbations to the flight plan, and as a result, we had the complete original Gemini IX flight plan memorized and worked out in a very orderly sequential step on how we would incorporate the rendezvous, the EVA and the Agena maneuvers and it was a very good flight plan as far as work loading of the crew. I think it carried every objective out unless we met a mechanical difficulty.

Cernan — We actually launched with two flight plans in mind, finally. One being able to dock and one not being able to dock. As a result, we were able to adapt to the latter without any difficulty at all. Even that changed somewhat. It was planned well and it worked out well.

11.3 Spacecraft Changes

Stafford — Very few spacecraft change items were noted in the pre-mission time. We did change components with respect to the computer and the radar. However, this had very little effect on our mission.

Cernan — The OAMS control power switch was changed, but this had little or no effect on any of our procedures and it simplified some of our emergency control system procedures.

11.4 The mission rules

Stafford — I thought the mission rules adequately covered all items that we hoped to encounter under this mission and we had very little objections or changes to the mission rules.

11.5 Experiments

Stafford — We felt that some of the experiments with respect to hardware, had not had adequate planning and crew input or coordination prior to the implementation of the experiment. In the period of time we had to train, we did not make any major perturbations as far as changing hardware at that time. We did the best we could with the hardware made available to us.

Cernan We felt that there were limitations particularly in S-1 and S-11 and we made these limitations known before flight. As a result, we took these experiments onboard and conducted them to the best of our ability with the limitations we expected and which certainly did exist.

12.0 MISSION CONTROL

12.1 Go/No/Go's

Stafford — I thought all the GO/NO/GO's were received right on time and in the time they were expected.

12.2 PLA and CLA updates

Stafford — The planned landing areas and contingency landing area updates were given in the format that we had discussed with the controllers prior to their deploying for the mission.

Cernan — I think the way that the transmissions were handled was such that there was a minimum of talk. The updates were sent up. If they were not understood, they were questioned. If they were understood, they were rogered. We didn't have to read continually back and forth everything that came up. The ground understood this and we understood this. I think that there was a great advancement in terms of communications, in not clobbering the air.

Stafford — I think this mission had the cleanest communications of any mission we've had to date.

12.3 Consumables

Stafford — With respect to consumables, I think the ground

[redacted]

should be complimented on the way they had all the consumables calibrated and the information they passed on, particularly in respect to OAMS fuel. They had this really adequately calibrated. Even though we were reading down to one and two percent on the gage, they were telling us exactly how many pounds of fuel and oxidizer we had. In fact, nearly to the minute, they told us when the regulated fuel and oxidizer pressure would drop, indicating need to activate the Volkswagen tank for the OAMS system. I thought this was really a great degree of accuracy in predicting this. Also, when we lost the hydrogen quantity readout, they computed the quantity from pressure and temperature and kept us completely informed as to the percent remaining.

12.4 Flight Plan Changes

Stafford — Again, I have to commend the Staff Support Room and the total Mission Control Center for the adequate update on flight plans and the flexibility with which the people had to operate for this mission. I thought everything was carried out in a very smooth, coordinated manner.

[redacted]

12.5 Experiments real time update

Stafford — These were given to us in adequate time for us to plan and execute the experiments. All the experiments were carried out on time. This can be contributed to the way in which the data was relayed to us. As far as the time to initiate the experiments and the sequence with which to initiate it, I though most of the experiments as conducted on the secnnd day after a full rest period, subsequent to the third rendezvous and the data that we received from the ground was excellent.

Cernan — Here again, the updates were just the essential information and there was no additional explanation needed, required, or given. As a result, again I think the communications was not one of explanation of the procedures, but one of just updating.

13.0 TRAINING

13.1 Gemini Mission Simulator

Stafford — Procedures. The procedures that were developed throughout the Gemini Program were used and refined on this mission and I thought all the procedures we had were certainly adequate to cover any situation. Systems Training. The total formal systems training for the crew was somewhat less than the other crews had had. However, we picked a lot of the training up in the emergencies that we requested be given us by the instructors. We also picked systems training up while accomplishing other phases such as rendezvous, and just operating the simulator. The launch phase on the simulator was very good and particularly the thing that makes it realistic is the noise level and the out-the-window display. In orbit, the simulator does very well as far as the platform modes and again, the simulator in the cockpit, is the visual display. The simulator crew responded very well. Everytime we had a change in launch date and time, they would update the starfields, so we had the starfield patterns for both the rendezvous and retrofire available to us in training.

EVA. The Gemini Mission simulator was not really used for EVA. This was done on the procedures trainer back at Houston and the adapter training that was available in the training building on MILA.

FCSD REP — Do you care to comment on the rendezvous portion of the GMS?

Stafford — Right. I thought that the GMS progressed a long way from what we had previously seen on it in rendezvous and we were able to use this GMS for all the various modes of rendezvous that we had anticipated to conduct. In fact, we carried four different types of rendezvous charts with us, because we did not know exactly what type of flight plan we would have. We worked out the fourth rendezvous about four days prior to the second launch attempt. The simulator had developed flexibility. It was a great contributing factor for us to be able to train in one day on this new type of rendezvous. I think the Gemini Mission Simulator provides all that the crew would ever need as far as rendezvous training after you've already seen rendezvous and understand the the problem. For the initial indoctrination to rendezvous, I still think it is probably better to have a concentrated workload on a hybrid simulator which has only rendezvous . So you use the computer, the platform and an orbital display or star map and not any of the spacecraft systems involved. Retrofire was simulated very well. There was nothing unexpected under retrofire in orbit that we had not seen on the simulator. Also, there was good correlation between the GMS and the spacecraft in the control authority and the OAMS system in all modes, DIRECT, RATE COMMAND, PULSE, HORIZON SCAN. Also, the way that the RCS section works is very good. On Reentry. I think, a large amount of the success of our reentry can be contributed to training and the way that the Gemini Mission Simulator performed. Crew Station. The crew station was updated to our configuration and, in fact, we had the control system change into the crew station at approximately the same time that the spacecraft had a control system change in to it. All in one day, which I thought was very good. In fact, we can sum up the GMS by saying that the simulator and the instructors all did an outstanding job.

Cernan — Besides the help and cooperation that the instructors gave us, the simulator itself was operational almost the total time that we were down here. This is the Cape Simulator. There were very few, if any, breakdowns and when there were, they were handled in hours that we were not going to use the simulator anyway. So, we had the simulator about 99 percent of the time operational while we were down here. The other thing that I'd like to mention about the simulator, as the Pilot and this being my first flight was that many, many situations in flight, both orbital and rendezvous, I felt very familiar with, I felt that I had been there before. I'd seen this type of thing in the simulator, which speaks very well for the simulator's ability to document what you really are presented with, in terms of displays in actual flight.

Stafford — The Gemini Mission Simulator has finally matured into a very worthwhile apparatus and it's available for training a large percent of the time. Also, the crew can work in it two shifts a day, plus occasionally a night shift.

The modifications and maintenance and repair to the simulator was done from midnight to six or seven in the morning and this worked out very good.

13.2 Launch Abort Training (DCPS)

Stafford

I think the DCPS is, again, a very valuable asset in the total training program. For this phase of flight, the DCPS is superior to the Gemini Mission Simulator and the training I received on that, I think, was certainly adequate. I think, one other crew-I think it was the Gemini VIII crew--recommended that you get your last set of launch abort training on the DCPS approximately three weeks before launch. All cases were covered. The audio, visual, and motion cues were very valuable in this case.

13.3 MAC Engineering Simulators

Stafford

The MAC Engineering Simulators with respect to rendezvous and reentry. We did not do any reentries on the MAC Engineering Simulators. The total time we were there, was spent on the rendezvous on which we did all three types of rendezvous that we performed on the Gemini IX flight. Taking a new crew into that simulator is the best way by far, to get familiar with rendezvous, to be able to handle failure modes, closed loop solutions, and also large dispersions The MAC personnel along with Flight Crew Support Division personnel provided a tremendous support team in giving us this training.

13.4 <u>Edwards AFB T-27 Simulator (AMU)</u>

Cernan — The Edwards T-27 Simulator was valuable within its capabilities for simulating AMU operation, however, since there was no AMU flight to compare it with, it is difficult to comment further on it.

13.5 <u>Translation and Docking Trainer</u> The translation and docking trainer

Stafford — was used for approximately 8 to 10 hours. From the experience gained on Gemini VI and Gemini VIII, it appears that not a large amount of training time is required on this simulator. I spent two sessions of over two hours each in a pressurized suit to practice station keeping. The original flight plan called for either station keeping with the Agena or the ATDA. I feel that it does serve a worthwhile purpose, however, the amount of time devoted to this individual training should not be excessive.

13.6 LTV AMU Simulation

Cernan

The LTV AMU simulation, again, was valuable. I feel it is worth repeating for future flights. It has its limitations, but without having had an actual flight on the AMU, it is difficult to evaluate its capabilities of simulating actual AMU flight.

13.7 Planetarium

Stafford

The planetarium. The Prime Crew did not attend any planetarium sessions after the first of March. The Command Pilot has not been to the Planetarium since last October. Unless there is a specific experiment involved, which requires an accurate track of the stars or accurate recognition and relation of the stars, I feel that this better served by the Gemini Mission Simulators. In this, you are in confine of the same vehicle that you will be flying in and you have the same visual pattern of what you will fly with and you can yaw, pitch, and roll to the various stars that you will have. So, I recommend that a minimum of time ever be spent on the planetarium unless there is a specific experiment that would require this.

Cernan

Also, in the GMS, they can very readily update your launch date, launch time and give orbital stars for redezvous. They are very realistic. Stars in the GMS are as realistic as the stars you find in flight.

Stafford — Since the GMS has developed this capability, it should be implemented with the regular training in the GMS and not separate trips made to the planetarium.

13.8 Systems Briefing

Stafford | The McDonnell Cape people provided all the spacecraft systems briefing when we first arrived at the Cape, and also the final systems briefing. I thought the job that they did was certainly adequate. It covered the latest configuration changes, and also the answers to any questions that the crew had for them.. The Agena and ATDA was covered adequately, the Agena by the Flight Operations Division from Houston and the ATDA by the McDonnell people. I think that this should be the continuing criteria for systems briefing breaking at the Cape, done by the contractor personnel that are at the Cape, since they are working with it in the final launch phase, and are very familiar with all the items. I do not think that any special team from Houston is required for spacecraft systems briefing.

Cernan | I felt all the briefings were very adequate, covered very well, and by people who either knew or could certainly get the answers for you. As far as the AMU, we had people from Flight Crew Support Division, from the Air Force, and from LTV who were readily available at any time to answer any questions or give any briefings that we needed. As a result AMU systems briefings and operational briefings were generally continued throughout the training program. It might be more valuable than I thought.

Stafford

The way that we scheduled zero g flight is probably the most efficient way it can be done. The aircraft was flown to Patrick from Wright Patterson. The crews alternated,the Prime Crew would fly the zero g airplane in the morning while the back-up crew had the GMS. The crews would switch at lunch-time, the Prime Crew would then take the GMS in the afternoon and the back-up would fly the zero g airplane in the afternoon. This way very little time was lost in total training effort, and no time is expended in transportation to Wright Patterson. We did not go down to the airbase until the airplane was ready to go. Very little support time was lost in this training. It's recommended that all future zero g training, be done here, whereas the regular R&D work can be done back at Wright Patterson.

13.9 Flight Experiments Training

Stafford — I thought the briefings were adequate. There was no sophisticated requirements for briefing. Equipment operation of the D-14 and the S-11 experiment, due to the design, was difficult. They were carried out adequately and on time, but the hardware should be relocated to facilitate crew tasks. The training for S-11 was rather difficult.

Cernan — In terms of experiment training and operation, my philosophy now is the same as it is for EVA operation. Make it simple to operate in one "g" and it's going to be adequate in space flight. But if it's a difficult task here, it's going to be an intolerable test in flight within the bounds required by the experimentor. Equipment and the operation of this equipment: we should think simple and I feel certain we'd get better results.

13.10 Spacecraft Systems Tests

Stafford — We participated in a minimum of spacecraft systems tests at St. Louis, and also at the Cape. The time can be more valuable spent in the Gemini Mission Simulator than doing a lot of pad time in the spacecraft, where only occasionally a function is performed and a switch is thrown. We did support the Joint

Combined Systems Test, the Simultaneous Launch Demonstration, and the final Sim Flight.

Cernan We also supported a great many systems tests which interfaced with the ELSS and the spacecraft. We supported them for confirmation of ELSS operation and to increase our knowledge of this operation.

13.11 <u>Launch Simulations</u>

Stafford Launch simulations with MCC here in Houston went very well. Both MCC and the crew, I felt, benefited a great deal from these. In one instance it appeared that the simulation people wanted to load up the people in Houston with them analyzing systems malfunctions. But, the way it turned out the crew did the total work load before the people in Houston got a chance to analyze it. However, there was no difficulty there, and we made all the retrofires on time and reentered. Simulated network simulations, provided some of the best training that we had with respect to the M=3 rendezvous. This was very valuable in looking at the type of communications we'd have, the type of burns and the vectors that were passed up to us. The regular network simulations should probably not be supported by the crew. This time was spent in regular GMS training. Reentry simulations were very worthwhile. However, I would say that the amount of both launch and reentry simulations that we performed should not be exceeded by other crews.

Cernan I feel interfacing the GMS with Houston, in the weeks prior to the flight, was one of the most active real time simulations. We actually worked with the Flight Controllers, understood their techniques, their problems. They get to know us, we get to know the operation of Houston chronologically and technically. I felt that that was a very, very valuable part of the entire training program, interfacing the GMS with Houston.

13.12 <u>Zero "G" Flights</u>

Cernan I feel zero "g" is valuable within a limited scope. Number one, it's valuable to practice something like ingress, which we know will be a difficult task. The only place you can get a true measure of the problems that an individual may have with ingress is in a zero "g" airplane. This is something that you just have to do and the only place it can be done is in the airplane. As far as working with the adapter, or work around the nose of the spacecraft, or any place else, my pre-flight feeling was that we should identify our problems and we should solve these problems. We should verify that they are solved in terms of hardware and in terms of hand holds or stirrups and routing of umbilicals. Identify these problems, solve them, and verify that they are solved. With the discovery of this slight negative "g" problem and the positioning problem that we had on Gemini IX, as far as the EVA Pilot was concerned, we might want to take another look at this problem in zero "g" flight not just in adapter work, but in terms of operating anywhere near or around the spacecraft. We should look at it in terms of closing spacecraft hatches, in locating spacecraft handholds, any number of things. I think we're probably going to have to take another good look at the fact that we are really not in zero "g". Rather than attempting to simulate zero "g", we want to attempt to simulate a very slight negative "g". This is almost the effect you get in the zero "g" airplane most of the time anyway. But, we had ignored the effects of any negative "g" in the airplane, saying that this was a Pilot problem in flying a zero "g" profile. But, oddly enough it's a realistic problem that exists in spaceflight. I have to withdraw a little bit of my condemnation of the zero g airplace training and say that we should take another look at it.

13.13 Air Bearing Table

Cernan — I felt that the Air Bearing Table training was not required.

Stafford — It would not be valuable because of your 6 degrees of freedom that you have in actual EVA flight. I still feel that way I haven't changed my mind although I can't really substantuate it in terms of maneuver flight. I recommend that the Air Bearing Table training be completely dropped.

13.14 MSC Altitude Chamber

Cernan — Two chamber runs were made at MSC. One in chamber B for hot firings of the AMU. There was a great deal of difficulty in getting the chamber cranked up and the equipment operating and this particular test slipped from week to week. After the people became familiar with the operation over at chamber B and everyone got on the same frequency, as far as procedures and safety precautions were concerned, the chamber test ran well. I think that they were worth while for hot firing of the AMU. However, I think that a good look ought to be taken into the bio-instrumentation and the respective harnesses that are required to be worn over there at chamber B. I think we ought to get in as truely realistic operational configuration as possible anytime that we are operating at altitude in suits. We were attempting to simulate what we will be in actual space flight. The other altitude chamber run was in the 20 foot chamber in Building 7, which was primarily with the Prime Pilot and the Prime ELSS. That chamber run was conducted very smoothly and I thought that the procedures, the people who were involved knew what they were doing. The whole operation ran as smoothly as any chamber run operation, I've ever been in.

13.15 Gemini Crew Station Mockup

Cernan

Gemini Crew Station Mockup was used at Houston many times for EVA preparation. Soft and hard suit preparation requirements and that, I think, turned out to be one of the key reasons why our EVA Prep went as smoothly as it did and kept the cockpit as clean as it did and gave us, as I look back at it, really no problems at all during EVA Prep. We had a number of walk throughs in the Mockup. Each one of which showed that we had a few problems which as a result were solved and I think came out in very good shape.

13.16 <u>Gemini Adapter Mockup</u>

Cernan — Same goes for the Gemini Adapter Mockup. We had one at Houston and one on the zero g airplane. We eventually used that mockup here with the AMU at the Cape. I think we ran through quite a number of EVA walk throughs with both Pilots. After all the procedures were ironed out, and the problems solved, the Command Pilot came into the program, and worked with the Pilot. We felt that we really had our procedures down and again, I think that this was very very valuable training contrasting this to the type of thing you can do on the zero g airplane. You cannot really get your procedures down pat and the adapter work on the zero g airplane, you can only identify and solve problems and become familiar with any zero g operation or any other problems that may appear in zero g operation. The procedural work is really accomplished in one g with the adapter

EVA walk throughs.

Stafford — I feel that the way that the EVA preparation went on the flight could be contributed directly to the training and the time and effort spent on the Gemini Crew Station Mockup. I am certain that this is going to be the same way in Apollo. The effect of training will be directly applicable to the flight.

13.17 Agena Mockup

Stafford — The Agena Mockup was used in October.

13.18 Agena Night Exercises

Stafford — This was the Agena night exercises at the same time. We had two night exercises total with the Agena and it was very worthwhile as far as looking at the way that the Agena would grow in relative distance to the vehicle. From this, we were able to again get a calibration of the reticle of the size of the Agena versus distance, and also use the sextant for range and ranging with the Agena. So, two or three sessions using the Agena at night is certainly recommended.

13.19 Stowage Training Equipment

Stafford — The majority of the stowage training equipment was used in conjunction with the Crew Station Mockup. In the last two months, prior to the flight, we did have adequate stowage training equipment.

13.20 Camera Training Equipment

Stafford — The cameras similar to the flight cameras were available again in the last two months. Prior to the flight of Gemini VIII, we had very few cameras and only had a Hasselblad available to us to use. After the Gemini VIII flight, we had all the cameras that were required for the flight.

13.21 Experiment Training Equipment

Stafford — The Experiment Training Equipment was available to us in adequate time for the crew to prepare for the experiments to be conducted on the flight.

13.22 EVA Walk Throughs

Stafford — We made a large number of EVA walk throughs and again, I think the way that the portion of the flight was conducted can be directly contributed to the fact that we did spend a lot of time on these EVA walk throughs and knew each line item by heart nearly. Also, we had a checklist that integrated both the items, the stowage and the time lines together.

Cerman

EVA walk throughs in the adapter were made under different type of lighting conditions. At first and until procedures were ironed out, they were made under bright light conditions. Then they were made under normal adapter lighting conditions. They were checked and made under sun light conditions and this paid...they were actually made without using any mirrors and doing everything by feel. I feel that the Pilot was familiar in all these areas and as it turned out, we had to go partially pen light, partially single light operation inthe adapter anyway. The thing I'd like to say about EVA walk throughs, the equipment involved. Close to the flight or later in the training, within three weeks of the flight, we finally got the equipment available on a standardization type basis. The training chest packs, the training hoses, the training configuration of each chest pack, such as teflon inserts for the umbilical connections, the umbilical, and the electrical jumpers. If we had five different jumpers, we had five different types of jumpers. If we had three different chest packs, we had three different configurations of chest packs. If you were in Houston, you might have been confronted with one type, not a great variation, but enough of a variation to alter your training. What I am saying is that we need and what I think we finally have as a result of our training on this flight, is some sort of configuration control of our EV training equipment, because training if of little or no value if you do not train with the type of hardware that you are going to be flying with. This was a gripe that we had originally, and I feel that we finally had some hardware (at least some of it, not all of it). Some of the hardware was configured on a standard flight basis. This was not just a gripe, but it was a real problem initially. We had wrong hose lengths, some hoses would not fit in certain ELSS and wrong connectors. Many, many things and the worse part about it was that thwere was no standardization involved in this equipment whatsoever.

Stafford — This item was brought to the attention of Gemini Projects Office and a large effort was made to effect standardization, however, it still remains in an area that requires some attention.

Cernan — I think that our Flight Crew Support Division has come a long way in providing us with flight type training equipment, even if it meant carrying one ELSS across the country in a baggage pod or in a suitcase, just so we would have the same type and a flight configured chest pack to train with. Training of any sort without flight documentation, without flight rendezvous books or without flight hardware, without flight pencils, without any small or bit item you can have I feel, is not a waste of time certainly, but you are not getting the most out of the training that you could be, if you had flight configured gear.

13.23 <u>AMU Firing</u>

Cernan — I felt that the AMU firing...hot firings were valuable. As it turned out, the Pilot had one ambient hot firing and did not have altitude hot firing, because of problems with equipment during the chamber B run. I think that ambient firing is certainly adequate, but if you can incorporate firings on the AMU at altitude with requirements of a chamber run for other reasons, such as the ELSS, it would be worth while to do so. Altitude firing runs on the AMU, just for the firings themselves, are probably questionable, because we determined that you could not see, hear or feel the thrusters fire. As a result, you don't really get much out of that particular type of altitude run. Incorporated with requirements on the ELSS, or on umbilicals, or on other type of flight support equipment, I'd say you could go ahead and do it, but otherwise, no.

13.24 <u>Equipment Bench Check</u>

Stafford: We had two major Equipment Bench Checks. One was in St. Louis, prior to the altitude chamber run and the second was at the Cape, prior to launch. The bench check in St. Louis was the best that I'd seen. However, there were still several items of GFAE that was not available at the bench check. The one held at the Cape was nearly perfect, and I think that we got about 99 percent of all flight items there. The exercise was a very good effort.

13.25 CAP COM Participation in Previous Flights

Cernan

The fact that the Pilot was involved in Gemini III, IV, VI, and VII, primarily as a CAP COM or as a Tank Pressure Monitor in Mission Control was certainly valuable experience, because I learned what the ground problems were and how the ground operated. I appreciated the equipment limitations and communications limitations that they had and got a feel for how a great many of the people and their personalities would react and how they thought. I don't feel that this is a necessary requirement certainly for a flight crew, but it is experience that I am glad that I had.

Stafford

Additional items of the debriefing that we know that should be improved is the GFAE cameras. With respect to the 16 mm movie cameras, the markings for the lens settings for focal length and the F-stop. It's very hard to see, unless you have your face right on top of it, in the position of the cockpit, and pressurize it is impossible to see them or make any setting.

It is recommended that you have large white or black markings on the lens settings and the focal length settings. Also the 16 frames a second, or the TEST position provides the most real time data of motion of any of the settings. However, this is the one position that does not have a hold for actuation. That is, the one frame per second, 6 frame per second, you can either touch your remote cable or the actuate button and continue to run, where on the test position you have to hold it down full time. The majority of the work that we are doing, you want to use 16 frames per second, so it is recommended that the TEST position or the 16 frames position be modified to where it will be a push to actuate. It will continue to run until it is pushed to deactuate. There is no adequate way of determining when you are out of film except to take your face, turn 90 degrees to camera body and place your eye a couple of inches .....

Cernan — Then you still can't see....

Stafford — You still can't see the amount of feet left. It is recommended that a light be put on the aft part of the camera body, that will be on as long as you have film in the camera, or else it can be off when it is still in the camera or when you run out of the film. In other words, you need a visual indication when you no longer have film in the magazine. Associated with this, as can be seen from the films of reentry, we have different lighting conditions and there is no way of changing the F-stop setting. It is recommended that the use of a photo-electric eye, that is available today, be incorporated in these cameras particularly when you fly in formation with the satellite or an Agena, anybody in space, or do a series of maneuvers, where you have varied lighting conditions over a short period of time. The automatic eye is the only type of mechanism that can compensate for this varying light conditions and still produce good useable films. Therefore, we have three changes, one the markings on the lens, so that they are visual from a good distance of 6 to 8 inches under lighting conditions. The addition of a circuit that will enable the 16 frame per second to be in a hold position, that is, one push button to actuate the runs as long as desired without requiring the crew member to hold his finger on the remote cable or the actuate button. And three the use of a photo-electric guide to give the proper F-stop settings for the light conditions involved. Actually there are four items. The fourth one that was previously mentioned, is a light to indicate when the magazine is out of film.

Cernan There was one malfunction within the camera and that was in the Pilot's 16 mm camera. This occurred Post EVA and I don't feel that it had anything to do with the EVA at all, at one time, it would only run in the 6 frame per second position no matter what happened to it no matter what setting it was in. It would only run at 6 frames per second. This occurred after I had been running at 6 frames per second for a long period of time, taking terrain photographs down the coast line of South America. I checked to see whether the camera was hot. It was maybe a little bit warm, but not hot. I shut it off and when I turned it on again, I could only get 6 frams per second out of it. A little bit later, the proverbial bump, with a hammer corrected this situation and it worked perfectly fine from then on out in all settings.