

Mr. Neil Armstrong interviewed by Dr. P.J. Vorzimmer - MSC - April 6, 1967

ARMSTRONG: You remember which things change in the course of the program, but you don't remember any more. I think some of the most interesting things to me are to read the Gemini mission plans or talks of what is intended for Gemini of about two or three years ago. Then you see what we actually accomplished. As compared with what was thought about at that time.

VORZIMMER: That's true. Our Chronology -- we've done a chronological his history which is just entries, like we did for Mercury -- has a lot of interesting things. Bill Tindall gave me four years of Tindall-grams which in some cases, they led me on to other things like the OAMS retro-maneuver. The story behind that was really an interesting one. That's the kind of thing that was pretty interesting. Also -- as you said -- the earlier mission plans where the idea was going to be that they were going to pop the hatch on III and stand up on IV..

ARMSTRONG: I think they were going to rendezvous on IV. I think they originally had an Agena scheduled for IV, if I remember..or something like that..

VORZIMMER: Well, they did have..they wanted to rendezvous with the spent stage of the rocket.

ARMSTRONG: No, this was before that. They were going to have an A Agena on IV, I think, originally. I don't recall that exactly, but I do recall reading some old articles that..gee, why had quite different thoughts a few years ago as to what actually was going to happen.

VORZIMMER: And then time-lines too. What they thought could be done in a single mission. It just sort of boggles the imagination now that people really understand the time-lines and the mission plans because the things they wanted people to do, it was just fantastic. And then, of course, Dave and I spent quite a bit of time talking about things that impressed him about the program and we were talking about how, as the time gradually approached lift-off, he was saying that when he went down to the Cape that he was so impressed by the apparent chaos and all the things which he was so intimately aware still needed to be done before, and he said that two weeks before the mission he said that they needed four weeks--it'll never get done--one week before he said "I still have my doubts." because a lot of things had yet to come in, so to speak, and then he told me about the little old lady who'd been brought in to sew on that extra thing on the umbilical and then he told me the story about the gloves. So this is good and interesting material because the intrinsic value of the item for the history might be small but as far as giving the public a picture of how a mission comes off, it's very valuable

Another thing which he was telling me yesterday which I didn't quite appreciate before was the fact that really nobody else can take over somebody else' Gemini mission because of the uniqueness of

each particular mission. I'm afraid that I felt that well, in a pinch, somebody who did a rendezvous before could easily substitute for somebody who is doing a rendezvous now..

ARMSTRONG: He could substitute, but not easily. It would take quite a bit of time. We make an effort to have the back-up crew ready to switch in at any time with no time loss. And we do, in fact, achieve this probably up until the last -- it varies a bit with the crew and the mission -- but something like the last week or ten days. After that, to change crews, would mean a little time slip.

VORZIMMER: That's the point at which you then divide the tasks -- is that right? The menial tasks...

ARMSTRONG: That's right, the back-up crew really acts as a service crew to the prime crew after that time.

VORZIMMER: Like stand-ins for the movies. They sometimes have to stand in for stuff while the prime crew is doing something else.

ARMSTRONG: Well, yes. Since there are many things going on at the Cape at that time, why the back-up crew runs over to one place or maybe they split too. Maybe one goes to the launch pad and one goes over to the Agena and the prime crew may be in the simulator and so on, just wandering around the backup crew makes themselves available to do anything the prime crew thinks needs to be monitored or done.

VORZIMMER: And you were the back-up for V?

ARMSTRONG: V and XI.

VORZIMMER: Well, that brings to mind a point and I'd be interested to hear if you have more of these stories..like preparations for the flight, you know, training and preparations, because there are a lot, I mean, I remember one case..Gus Grissom, he was in the white room when a guy came in with that frog experiment-- I think it was S-3. He was wondering 'what the hell is that?' And he said 'that's the frog-egg experiment'. And, you know, he had a dim view of that to start with and that was the one he had to reach backwards to turn the handle..and then the handle broke..and he said 'the god-damn thing wouldn't have worked anyway!' You know, he had sort of a dim view of because the experimenters, at that part of the program, hadn't learned to..didn't know what it was like to live according to schedules and didn't know what flight qualification really meant and they were bringing in stuff at the last minute.

ARMSTRONG: Right. And both the experimenters and the crews learned a lot. During the course of the Gemini program, in the earlier phases the relationship between the experimenter and the crew member was well developed or understood at that point and the experimenters felt like they'd just stick it in at the last minute, whatever it was, then tell the crew what to do and bring it back and the crews felt that they didn't want things in the spacecraft that they didn't understand or have integrated into their time-lines so that they were sure they didn't or wouldn't foul something up in the

process. Well, both views were not quite correct. By the middle of the Gemini program, I guess, the working relationship between the crew members and the experimenters had developed very well. Primarily, each understood that some initial work had to be done together so that the crew understood what the experimenter was trying to do and the experimenter understood what the constraints of the mission were on the operation of his experiment. When I was first in a crew, on Gemini V, this was not well understood and there was a lot of battling back and forth between various groups. By the time we got to XI which was the last crew I was on...

VORZIMMER: Now V was really bad. In fact, there was a lot of door-slamming going on around the building and various other places. Cooper -- that was the one where he really let it be known at fairly high levels that he wasn't going to put up with this sort of stuff because the time lines were getting ridiculously short and there was no time to train on these things. He was saying something about pushing the flight...

ARMSTRONG: Yes, we actually did slip the flight..two days. We were computing our training hours pretty much to the hour required and it looked as though two experiments just couldn't be covered on the launch date that as proposed and we told Deke that we couldn't make it and he went to Washington and I guess he told Mueller that if he wanted these two experiments it would take some additional time. We did compromise on a two day slip on the launch date so that we'd have enough training time. In V that was a peculiar situation because we were assigned rather late. That is, there was only five months before launch date before we were assigned. And that was rather late. V was a rather complicated mission. There were the fuel cells which hadn't been flown; the first radar; did the first rendezvous exercise using the REP package -- didn't really occur, but we certainly had to train for it; had this large number of experiments and we were really pushed on training time. So we were really pressed to get everything done. The large number of experiments had a large training time requirement and consequently we had to budget our time pretty closely to get everything done.

VORZIMMER: Well, there was actually a meeting where..I guess that one of the alternatives was to bump those two experiments..wasn't it?

ARMSTRONG: Yeah, some of them.

VORZIMMER: The ones that Cooper wanted off were DOD experiments I believe and some Air Force general really put the screws to him. He reminded him that he was still in the Air Force and a few things like that and Cooper said he didn't give a damn and slammed the door. This is the kind of thing that won't be in the history but..well, the pressures really did build up on that time line. It sounds like most people thought "Ah, eight days. We'll have plenty of time to do all sorts of things." And in fact it's sort of Parkinson's Law that things always manage to expand so as to fill up the available time, if not exceed it.

ARMSTRONG: Things certainly do. There were some hard feelings engendered

because of a meeting at Wood's Hole during this time period where a lot of the scientific community was there and one experimenter expressed the views to this gathering that the astronauts weren't cooperating and they were trying to throw the experiments off the flight.

VORZIMMER: Yeah. I got this when I went to Washington and interviewed the people there in the Experiments office. They felt very maligned.

ARMSTRONG: It turned out that this particular experimenter had an experiment on the flight and he had gross misrepresentations of the operational constraints and had he done..had the experiment been done as he proposed he would have gotten no results at all because he didn't understand certain geometric relationships in the spacecraft. This was Ed Nye. He didn't understand how the camera was pointed in the spacecraft -- the interrelationship there. Had it been done according to his directions, it wouldn't have gotten anything. Well, subsequent to that meeting we got him to come to the Planetarium and we pointed out with the aid of some various devices in the Planetarium that the..he himself didn't understand the problem. We were trying to tell him we couldn't manage and he soon realized that that was true. The experimenter and the crew worked out a procedure together that would get us the kind of data that was intended to be achieved. He realized, after that, that there has to be a joint understanding of these problems pretty early in the schedule to work out a technique and the training that will get the job done. We had him again, in another experiment on VIII, and we got together pretty early and had a good relationship subsequent to that time. I think that did the Program a lot of good because a lot of the related experiments -- in was the Dim-Light Photography primarily -- were pretty successful after that.

VORZIMMER: Well, one of the problems was that -- as both Jocelyn Gill and Norm Foster indicated to me -- there wasn't an office of experiments that would really handle the interface problems between the astronauts and the experiments. There was a physical interface in that they had these experiments monitors...

ARMSTRONG: It's not so much the astronauts..it's really the space-craft, for example there was an experiment performed on a couple of flights that had to do with taking spectrographs of starlight. It was complicated by the fact that in order to take a spectrograph you have to get an exposure on a piece of film that'll show a line. That means you can't be moving the camera around. The fact was that the control system of the spacecraft was not aligned with the camera mount. Second, a very small input ~~that~~ the control system was capable of, was larger than that necessary to hold the line at that particular place on the film during the exposure time. In other words, the very smallest motion of the spacecraft--of which was achievable--was too large to hold the line on the place on the film for the length of time of the exposure. This had nothing to do with the astronauts. It was an operational consideration. It was the crew, in this case, that pointed out that the Agena control system, however, was capable of smaller increments of motion particularly while you were docket. It had a large mass and high increment of inertia, and it was easier to hold that still, or its reaction to a small jet firing was small. Second, the Agena had a control system

whose exhaust was cold nitrogen rather than the hot gases from a bi-propellant rocket like the Gemini and since that exhaust was luminescent it would affect the film and the nitrogen would not, and if it did, it would only put a nitrogen line on the spectrum. So this was fairly significant and, as a result of that, we found a technique using the Agena control system that enabled us to take spectrographs that actually had reasonable lines. You see the situation here..there was not a problem between the experiment and the astronaut, it was a problem between the experimenter and the spacecraft. It turned out that the crew was the sort of intermediary here. They are the people that uniquely know all the aspects here. It's not a matter of personality or the people..

VORZIMMER: But they still needed the briefings. You still have to be assured of the proper briefings so that you can spot these problems.

ARMSTRONG: That's correct.

VORZIMMER: And there are problems..where there had to be a more direct in put, such as, you know, on the ground they cock the shutter and advance it, they use their fingers, they're not used to --they don't know about the gloves, they don't realize that, in some cases, there's a difference between an EVA glove, or about putting lanyards on magazines and things like that, so that..but this, it seems to me, is where the organization of the program was pretty good, in that there was always an astronaut, or somebody who took the astronaut point of view, at these early panel meetings which configured and designed these things.

ARMSTRONG: Yes, that's true.

VORZIMMER: I'm going to interview Rusty Schweikart, because he made some very good inputs--by adding the note of practicality and reality to some of the designs that people wanted to put in. Dave Scott was giving me some pretty good stuff -- you know, they don't realize until they get everything together. You get the chest pack and the back pack together and something happens: the astronaut can't reach around and make hook-ups, fully suited, that..and then of course, each guy -- the man who makes the chest pack things the guy who made the back pack will make the link..or electrical plugs that look pretty good and yet you're in the back, in the adapter section, in the dark or near dark, and you can't even see to put it in. It's amazing. You know, I can appreciate the wonderment, when you're sitting there in the white room wondering how the hell it all managed to get there at one time, in time for the lift-off. And then of course I asked him, "If you're that amazed, aren't you also equally worried that, just as you lift off, there won't be some little guy running onto the site with some piece, saying this is something we forgot?" But if everything manages to converge at the last minute, you must also wonder if there is something that hasn't converged. Because it is pretty impressive when everything gets done. Mike Collins, on the other hand, was telling me that there are cases where they converge and it's too late. He was telling me about the camera and the mount he had made for it. During training, the two pieces that he had were perfect, but they weren't the real flight articles and when the flight articles came together; when he put them together, they didn't fit.

ARMSTRONG: It's an unavoidable battle. At first you want to have the things available as early as possible so that you can have lots of time to practice and work out any kinks that might be inherent in the operation and second, you want to have the equipment as late as possible so that it can be the very best equipment possible and incorporate all the latest changes and so on. So these are two diametrically opposed points of view and they're both valid, so you have to find some point in the middle that's acceptable from both points of view and our problem has always been this middle of the road time has always drifted back towards the flight time and it's become closer to the flight than it should. Some items, invariably, some last minute items pop up out of nowhere. You just have to hope that they won't give you a problem but sometimes..

VORZIMMER: The best story he gave me was the harness piece. After they'd already been inserted into the spacecraft. He said that's the first time he ever saw Pete Conrad sweat as he was standing there with that..

ARMSTRONG: Taking the epoxy out of the harness.

VORZIMMER: That's really last minute.

ARMSTRONG: That was a good story.

VORZIMMER: Now that wasn't anywhere in the record. That's the first time I got ahold of that. That'll be worth putting in -- definitely. Also, in a footnote, Dave saying that if he just managed to get it in --he wasn't worried about the fast-disconnect because the ejection and the abort situation would have required a fast disconnect. He just wanted it so that it would just fit, just stay there..then he would have flown with it anyway..and he knew that Pete would have said the hell with it too..not to hold up a big thing for...

ARMSTRONG: They've got so many millions invested in that thing..

VORZIMMER: It must be aggravating. You're already inserted, and the guy has to sweat over you at the last minute. Well that reminded me..on last minute working on the thing. There was just enough time to pull his hand out and close the hatch. As far as training was concerned, for either the V or the VII or the XI missions..have you got any any items as far as inputs that were made during training or that changed something or that came up at the last minute. I'm thinking of stories like the gloves or not realizing that the electrical line was long than the flex.

ARMSTRONG: I'm sure there are hundreds of stories.

VORZIMMER: Some that might stand out in your mind. In the history you can say 'Yes, training was long and complicated' but sometimes by adding one or two such items for each mission, the person who's reading it can get a better picture than if you just say it was long and complicated and took many hours. You know, you can give examples of problems...I found out that there was an instance

of underwater training for EVA before the X, XI, XII end of the program and that was when Dave went into the tank to practice with the HHMU underwater. And it was part of his feeling that it wasn't very helpful that sort of...

ARMSTRONG: The gun just didn't work underwater

VORZIMMER: Right, it wasn't giving enough moment. But that was another example of those small things that..because, in fact, that did have an effect on whether they were going to think about underwater training for IX, X, and XI WHICH they didn't and which they probably should have.

ARMSTRONG: Well, there are some things that the water is good for and others, well, it's a matter of time decided--it's taken us time to decide where it should be used and where it shouldn't. I'm not sure we still know that as well as we should, but with increased practice I suspect we will eventually know just what things we can practice underwater and which we can't. Zero G training has always been a problem for us. How much to do. Dave will tell you we did most of our stuff in airplanes. Dave did some 300 parabolas getting ready for VIII. I, who had less to do, of course, because I wasn't going to go outside the spacecraft, still had about 200 parabolas for that flight.

VORZIMMER: It seems that the difficulty about that was that there was nothing negative about the weightless condition that might indicate water would solve it -- do you know what I mean? -- so that the things that were lacking one was not made aware of.

ARMSTRONG: That's right. If we found a problem, we pursued it. It's the problems that you never find on the ground, that you only find when you get in flight that are the ones you're always worried about.

VORZIMMER: I guess there weren't too many other solutions at hand so far as achieving zero gravity simulation..and that was rather sporadic. You get 25-30 seconds at the most and then you sort of have to reconfigure to come up again to do another one. So you don't get any continuous zero g..so that no soon do you get to the edge of a problem area than the gs start building up on you.

ARMSTRONG: Yes, so some things you never discover just because the limited amount of time you have available in the airplane. We hope that the combination of air and water will work now.

VORZIMMER: I'm surprised that water didn't come up earlier.

ARMSTRONG: It did come up. As a matter of fact, even the Mercury -- they did underwater training. The guys went through Scuba school and everything. They would get used to weightlessness by going under water. As time went by this was discarded as not being sufficiently worthwhile.

VORZIMMER: But that was just for weightlessness, now what about water

for EVA WORK tasks and things like that?

ARMSTRONG: It wasn't really pursued because the feeling was that the -- it wasn't sufficiently representative: the viscosity of water, the slow motions you were restricted to, and so on. So that we've been around the cycle here a couple of times. I imagine a little bit about rendezvous, if..there was a question in training about how much rendezvous experience --practice, simulation--was required in order to give you the confidence that you needed to go ahead and try to fly a rendezvous. VIII, of course, at the time we started, no one had completed a rendezvous and docking, and while we were in preparation 7/6 was flown-- the first rendezvous of course. Since VI had had a couple of aborts, as you remember, and gone through a couple of clutching exercises there. They had really had a large number of rendezvous simulations. It seems to me it might have been something around 70 complete rendezvous in ground simulators of different types. We didn't have that much time but we achieved 50-some rendezvous simulations on the ground, about 2/3rds of which were with some sort of emergency. That is, with some part of the equipment either malfunctioning or inoperative during the rendezvous. In the 50-60 rendezvous we completed on the ground, we only missed 2. That is, we completed the rendezvous in all but 2. And during the 2 that we missed, there was a malfunction of the simulation so that we never -- in other words the equipment blew apart in the middle and we never knew whether we would have made it or not. So that we had very high confidence level that, if our simulations were accurate, there wasn't any question of us completing the rendezvous. What we were concerned about was, if something goes wrong, it's usually something that you never thought about. You can practice all kinds of emergencies and failures and when one occurs, why, it's the one you never practiced because you never thought about it. So that's the sort of concern we had.

VORZIMMER: You certainly proved that out, didn't you?

ARMSTRONG: Well, in the rendezvous case we had not that many problems. It was very much like what we had expected..

VORZIMMER: Getting on towards that thruster problem, Dave said that you'd practiced by looking at the ball, how you could tell what thruster, if you had a thruster fail on -- which was unusual in itself since the history of Gemini had been the history of thruster failure off of degraded -- that you could tell by looking at the ball but that nobody ever thought of linking up the Agena and seeing what would happen by a ball indication in that case.

ARMSTRONG: It was true that the -- although we looked at lots of failure modes, the one that we experienced really was a little different than any -- though it was true that we had a similar one with a spacecraft thruster simulation shortly before the launch, except that we weren't docked with it at the time. And of course when you're not docked, it's fairly easy to tell or diagnose the problem. We found out that when you were docked, it was considerably more difficult. In fact, he said that this was one of the things..we were discussing trying to get a good line on the logic of the situation that you were in and he was saying that one of the two or three inputs -- I forget now whether it was two or three -- before the problem actually began that led you to believe it was the Agena was (a) that RKV gave you an input that said they were having problems with the Agena before you got there -- and another one

was that because you had done this training with the ball to isolate spacecraft thruster problems, and because the ball was acting differently when you were docked that led you to believe again that it would be the Agena that was misfiring because you knew what the spacecraft thrusters would be like. So that that helped complicate the situation if anything.

ARMSTRONG: There were some other complications. You had a lot of other factors entering into a situation. It's always a little bit difficult to search out those that are giving you right indications and those that are fooling you. We had several that were fooling us. One significant one that was fooling us was the fact that we had sent a command to turn the Agena's rockets off yet in a few isolated instances we could see that they were firing, which indicated that it indeed did have some sort of a failure because it was firing when it shouldn't have been. That led me to believe that there was something wrong in the Agena control system. We saw the Agena engines firing -- we could see the exhaust of the Agena attitude system -- and this was after we had sent the 'OFF' command. So that was confusing but since we were sending a lot of commands. We didn't see the Agena exhaust until we came into daylight, or just before we came into daylight when we had an illuminated horizon. Prior to that we couldn't see anything.

VORZIMMER: You had solved the problem the first time, or you thought you had solved the problem because you had managed to counter it and this is because it had only been firing for three seconds or something and then you had managed to damp out the thing and then it started again. In other words...

ARMSTRONG: Three minutes on, then four minutes off, then three minutes on..is the best we can say..

VORZIMMER: Just a second -- you mean the first time it was 'minutes'? I thought seconds, then minutes..

ARMSTRONG: No, there was intermittent firing at first..but I don't recall seconds..there were seconds involved at the first, then minutes..then it came on and stayed on for three minutes, then off four minutes during which we thought we isolated the problem..then it was on for three minutes again, during which we undocked and shut the system down.

VORZIMMER: Alright, going back over the story now, Dave says that you were doing something and had your eyes on the interior of the spacecraft and he was reading down and just about to push the third number of the record message to the Agena and he was reading it off to you and he said he was going to look at you for something and his eyes went like this and he caught the ball on the panel because you were both unaware because the rate was so slow...

ARMSTRONG: He called it out. I was around looking at the back.

VORZIMMER: And then he said he saw his ball and even then he couldn't believe it, so he looked over and saw yours and saw that

you really were in this roll and then he said 'Hey, there's something wrong' and that was the initial problem and then you damped out that motion and managed to get aligned once again, before it started again. Now, up to that point, you still hadn't seen the Agena firing.

ARMSTRONG: That's correct. It was much later when we saw those rockets firing. This was after we knew we had a problem...

VORZIMMER: And just before separation.

ARMSTRONG: Yeah..I'd have to look back to the records to find out when we came into daylight. It was during the time we were just coming into daylight..so it was before we separated, because we separated in daylight.

VORZIMMER: How long did the whole sequence take? I mean I guess we can find that out in the transcripts, but approximately..just to refresh my mind.

ARMSTRONG: The whole thing took about 15 minutes.

VORZIMMER: It did take that long. I see. As I had it in my mind, it was all within a much shorter period of time than that. I guess what was fairly fast was after you had separated and the roll rates had gotten to this very fast..one rev per second.

ARMSTRONG: It was after we separated that we got those rates.

VORZIMMER: And that's when things started happening fairly quickly. So this OAMS to RCS and back to OAMS and then back to RCS that..

ARMSTRONG: That all took place in less time..a minute..

VORZIMMER: That must have happened quickly because if, as I asked Dave, you went back to OAMS to reconfigure the switches and then go back to the RCS, in the ordinary sequence of going to RCS you would have made sure that the switches had all been configured in the first place. In other words, you had to go back to the OAMS system because of the ACME bias problem..

ARMSTRONG: That's right.

VORZIMMER: But ordinarily, if you had plenty of time to go from OAMS to RCS -- like before Retrofire -- you wouldn't have had that problem with the switches. So that gave you an added little pang there because when you went from OAMS to RCS you hadn't improved your situation at all, the first time around. So it must have been with some sigh of relief...well I guess you knew that you had gone through that ACME switch ..no I guess you didn't because you didn't know it was a logic -- an ACME bias logic -- problem that was doing the..

ARMSTRONG: That's right we didn't recognize that we had -- didn't have the electrical continuity correct to fire the RCS until after it didn't fire. At that time our roll rate was so high that it was

difficult to read the breakers..looking up and to the right..nystigmus

VORZIMMER: So that was pretty hairy then when you went to the RCS and didn't get what you thought you were going to get..

ARMSTRONG: Yeah, you bet it was!

VORZIMMER: That's like finding yourself with a dead stick in an airplane. But you knew almost immediately -- I'm trying to analyze your thoughts at this point -- you still had the possibility of reconfiguring the switches..

ARMSTRONG: If I could read them...

VORZIMMER: Well, it sounds like it was more of a problem with you than Dave..he said that it was hard to make out the numbers..

ARMSTRONG: Well, the only question was whether, since the roll rates was continuing to increase, how much time we had before we couldn't handle physiologically the roll rate or what that would be. We knew that it was going to be sometime soon because we were continually increasing in rate.

VORZIMMER: And yet once you had reconfigured the switches and gone back to the RCS you were very very ginger about handling your RCS movements. You did one at a time, you didn't put it hard over.

ARMSTRONG: Right. Because we were on our last system and we had to... once we knew we had control...

VORZIMMER: You didn't have a choice, you had to activate both rings.

ARMSTRONG: Yeah, we had to activate them both simultaneously.

VORZIMMER: This was a change over the early Gemini configuration, Dave said something about this. There was a point in Gemini where the rings were configured..

ARMSTRONG: That's correct. Early in the program it had individual rings.

VORZIMMER: So I guess you kind of wished you only had to break open one ring.

ARMSTRONG: Yeah, we did. Had we been able to do that, we could have continued the flight.

VORZIMMER: You think you could have argued the ground out of the mission rule?

ARMSTRONG: I think the mission rule wouldn't have existed in that fashion had we had two rings individually -- 'isolationable'? But once the integrity gets broken on both rings, why mission rules certainly had to stand as they were.

VORZIMMER: But it sounds like you both would have been satisfied, since the ground had such a good system for monitoring possible RCS

leakage. It sounded like you were both willing to play it by ear as far as flying with the ring activated and carrying out the mission. You would have been willing to take the chance of a contingency landing area...

ARMSTRONG: Well, I knew we had all the people on the ground wanting us to fly as long as we could. They demonstrated that on previous flights -- on V for example -- when they had severe problems and they demonstrated that they were interested in keeping it up as long as possible and I knew that there were people on the ground from our own office and from others who were interested in keeping us up if there was some way we could do it, so I didn't argue that point. We were sure that if there was a way they could keep us up..although I wanted to stay up. I was sure that it was reasonable to do so. There were people arguing on the ground at the time -- I didn't have to get into the fray.

VORZIMMER: But it must have been tough because you -- there is a sense in which you could have played it by ear and just let them monitor your RCS. If it came up later you could always come down. If there had been some degradation or leakage in the system.

ARMSTRONG: It was a question of..

VORZIMMER: ..Or was that not the only problem?

ARMSTRONG: Well, it was a question of the available landing areas. If you had to come..we missed the -3 landing area..then what kind of problems might we be in if we had to go in the -4s..they weren't so good. If you remember right we had all the people in the rescue business looking for the Andrea Doria for a day and a half you remember, and they couldn't find it. That was a big ship and they had all their radios going.

VORZIMMER: Oh yes, Dave said something about the ball, and that you introduced the idea of putting degree marks on the ball, and that it's now on Apollo. The original ball didn't have degree marks on it?

ARMSTRONG: That's right. It was marked -- I don't remember exactly, I think it had ten degree marks or thereabouts -- thirty degree marks in some places. Our alternate rendezvous procedure had indicated that it would be desirable to be able to take measurements directly off the ball to a greater accuracy than was possible with existing markings. Several of the astronauts from this office were involved in promoting that view in addition to myself. We went to the program office and asked for -- first we did a study right here in our own shop, using one of our own simulator attitude indicators and putting 1 and 2 degree marks on various places and trying to use it. I had thought that we probably wouldn't have success with better than 2 degree marks. I thought that was probably a limit to the resolution of the eye in combination with the attitude indicator with its parallax problems and so on. We felt strongly after trying the actual indicator with the marks on the simulator that one degree was a usable system and you could probably read the attitude indicator to half a degree which was a very useful thing from the point of

view of the alternate procedures because that, you see, was the key to the whole deal. We approached the program office then to remark the attitude indicators in the spacecraft. The cost was high and they were reluctant to do it but they accept our arguments -- in the case of VIII they said 'alright, one attitude indicator, the one on the left side, but we won't bother the one on the right side, so if the thing crumps out because we violated its integrity somehow by remarking it, that at least you'll have an attitude indicator to fall back on'. And so VIII was the only spacecraft to fly with one marked and one not marked. It was very useful. It was accepted that after that flight that it was useful and that there was no degradation, so that all the attitude indicators for the rest of the Gemini program had one degree markings on both sides and of course the Apollo ball has them also.

VORZIMMER: I was surprised to hear on the sustained firing of the OAMS thrusters, that you got this mushy degradation -- and that the system can actually just give out.

ARMSTRONG: These thrusters all have a limited lifetime. So many seconds of operation and they're expected to degrade -- either the valves or the chambers themselves will degrade -- to the point where they're useless or near-useless.

VORZIMMER: And yet -- as it was in your case -- before retrofire, you were able to align using your own -- Dave said you got pretty good control on them.

ARMSTRONG: Fairly good control at the end was regained. Apparently at the end it was primarily a temperature problem. In other words that they burned continuously and they got hotter and hotter and hotter and stayed quite hot for an extended period of time and once they had cooled down after a couple of hours of cooling, why the operation of the chambers and the valves became pretty good again.

VORZIMMER: Because if you hadn't realized that they would get better than even being able to -- even suppose you had the isolated ring and you convinced the ground you didn't have to call it off because of the rule, you would have problems anyway..

ARMSTRONG: We had to consider that we might have to use the Reaction Control fuel which was already limited because we burned a lot to arrest the roll rate..we had to use the Reaction Control fuel to align the platform, the inertial platform so that we could navigate back to the ground. And it takes about half-an-hour's fuel to get the platform aligned well enough to do a good job of navigation during re-entry -- and that was some significant proportion of the available fuel remaining. It was real helpful to be able to use the OAMS fuel instead.

VORZIMMER: But you didn't know that at the time when you still had this feeling you would like to stay up -- what would you have anticipated doing staying up since if you knew that you had to reserve the RCS for possible alignment..you couldn't have done EVA because even then you needed a certain amount of OAMS to

ARMSTRONG: We couldn't have done it in the manner we had planned, certainly. We might have been able to do one away from

the Agena so that there wouldn't be a fuel -- or we could have done it docked. The Agena was operative -- let the Agena control system do the job. But we could not perform the flight in the manner we had intended.

VORZIMMER: I never realized how much VIII was intended to do..how much it fitted into the program. But it sure was an important intermediary step between what had gone before and what was going to happen on IX. It was really heartbreaking with all that was planned and all that was carried..

ARMSTRONG: It was the first grandiose flight, I guess. It had a little bit of everything in it. Like every one after it.

VORZIMMER: You had EVA and rendezvous and docking, both. And then on top of that you had a good load of experiments -- you flew that Orthicon...

ARMSTRONG: That's right. Of course, as was shown in later flights, those kind of flight plans were possible.

VORZIMMER: But only really on XII though, if you discount the difficulties of EVA on XI. Well, no, I guess X had rendezvous, docking and EVA.

ARMSTRONG: Well, it didn't have docking.

VORZIMMER: But IX had problems -- I meant without any problems.

ARMSTRONG: Well I was speaking from the point of view, how much stuff could you pack into a three-day flight plan. I guess that IX through XII all showed how much you could pack in. VIII was a flight more like those than the previous flights. It was the first flight with a lot of stuff packed in to a 3-day plan.

VORZIMMER: Now, if by VIII, let's see, they would have had the IX crew picked, and the X crew picked -- was there any feeling that 'we got cheated..can we get put on as prime crew for a later flight?' I know that might sound like a silly question, but..did that come up at all?

ARMSTRONG: I know that there was a strong feeling in both Dave's mind and my own that 'Gee we'd like to go again two days later' because we were all keyed up to fly and we hadn't been able to do as much as we wanted to do so we both had a strong feeling that we'd like to jump right back in the spacecraft and go again, but it doesn't take very long for time to mellow that argument. You realize that that's not a possibility -- to get right back into the cycle.

VORZIMMER: But what about for XI or XII -- you couldn't fit back in for a later mission? Or are they really that keen on baptism-by-fire that they figured you'd been -- that all the months of training and the so-many hours of your mission was sufficient not

to put you back in for Gemini -- was that it? I mean if they wanted to, they could have -- they hadn't selected the XI or XII crews...

ARMSTRONG: I can't answer the question, because I don't know what their thoughts were on crew selection.

VORZIMMER: I see. Well, did you let it be known that you wanted to hop on another Gemini flight?

ARMSTRONG: No.

VORZIMMER: You just sort of left it in the laps of whoever-it-was that decided.

ARMSTRONG: Yes.

VORZIMMER: You had some problems when you did get down, didn't you? It took a long time to get the collar attached...

ARMSTRONG: I think that's just because the swimmers were seasick..

VORZIMMER: The swimmers were seasick?

ARMSTRONG: It was pretty rough water. They were pretty sick.

VORZIMMER: How about yourselves?

ARMSTRONG: Yeah, we were sick too. I guess they were worse off than we were, really.

VORZIMMER: Oh yes, I see from my notes.."nauseating odors from the heat shield and residual fumes from the RCS, hot spacecraft and rough seas caused the crew to be"...pretty green. And in there for three hours. You didn't get much of a break there.

ARMSTRONG: There was one advantage to being on a low residue diet. You don't have anything in the system to throw up.

VORZIMMER: Though I've never been seasick, I've had some friends tell me that the dry heaves are just as bad as the wet ones... I see here that you had a reserve OAMS tank on yours -- that you had more OAMS fuel than before, on any previous flight.

ARMSTRONG: Yes, but there were so many configurations of the OAMS propellant system throughout Gemini that just about everybody had some little more than somebody else. It changed on every flight...

VORZIMMER: But it wasn't a question of a significant amount of extra OAMS fuel?

ARMSTRONG: Oh no. It gave you -- it's like a Volkswagen. We called it the Volkswagen tank because it gave you about another gallon.

VORZIMMER: I see what you mean. What about XI? Would you like to say anything as the back-up for XI? As far as the training or

any inputs?

ARMSTRONG: Well, XI was a particularly interesting flight. One, because of the uniqueness of the things that were done: the one-orbit rendezvous was a particularly unique thing. Everybody had been studying the longer-time rendezvous for a year but the one orbit rendezvous was done on really quite short notice and the techniques were worked out by a team at McDonnell but procedures were developed at -- engineering simulations were done pretty much by the crews themselves. The crew really participated in the development of the technique -- and no one else did. There wasn't really anybody else in the world that knew how the one orbit rendezvous was going to be done. The crew and a couple of guys up at the plant..

VORZIMMER: What about Buzz? Was he in on it?

ARMSTRONG: No..I suspect that since Buzz has a very good knowledge of rendezvous, in general, that he knew the idea behind the thing but the actual detailed development of the thing he wasn't concerned with -- as I remember, he wasn't involved. Just was the crew themselves that really worked out the procedures and the charts..

VORZIMMER: Was the decision to make it an M=2 rendezvous in Apollo before that? In other words, Apollo was already committed to an M=2 rendezvous..

ARMSTRONG: I would be hard-pressed to recall the exact sequence of decisions.

VORZIMMER: It sounds like it was. It sounds like it would have been earlier in the Gemini program, because I think I remember Buzz or somebody telling me that M=1 rendezvous was not necessary for Apollo -- that it was just a question of proving something could be done...

ARMSTRONG: I think it was a very good exercise to do, because it was a minimum time -- a demonstration of a minimum time performance of a rendezvous. From our view it was a real good exercise and it made us, by requirement, look into some areas that might not otherwise have been investigated. I felt at the time and still feel that it was a very good exercise for increasing our over-all understand of the rendezvous problem. Then there was the high-orbit exercise which I think you'd probably get a good deal more from the other members of the crew..like Pete.

VORZIMMER: Were you in on that decision, when he went around trying to sell that high-orbit rendezvous..were you with him on that?

ARMSTRONG: No, I wasn't. And that's why I say that they're really better than I am on this area. I was tied being Cap Com on Gemini IX at the time that this particular discussion was going on. This was the Spring of 1966. I was operating as Cap Com, getting ready in the simulations on IX at that time we were trying to put together the flight plan

for XI. This was the time that Pete -- with a lot of help from Dick and Bill Anders sold the high-orbit. A great sales campaign.

VORZIMMER: This brings to mind one other question. Who decides, when you've completed your Gemini mission, whether you're going to be shunted immediately to the Apollo program -- because it seems to me that especially towards the end of Gemini there was no nonsense, you just got shunted straight over -- or whether you're going to be the Cap Com or the back-up for a subsequent mission?

ARMSTRONG: We used the technique as much as we could, of using the person who had just come off a flight to participate as the Cap Com on the next flight -- at least one of the people on the crew from the previous flight, because they weren't too involved in some other exercise. It was just a couple of months after their flight and they weren't too deeply involved in something else. That was the prime reason for that. Since I had just come off of VIII, I was on the Cap Com assignment. As for the remainder of the question, I don't know if you talked to Deke yet, but I suspect he's the man to help you. So you can get a little bit of philosophy in that area, because, in the end, he's responsible for the assignment of the crews.

VORZIMMER: And what about the decision about two month launch centers? If you were back-up for V, then VIII, you were affected by this shift...

ARMSTRONG: Yeah, we sure were.

VORZIMMER: Do you have anything to say about that?

ARMSTRONG: No, I guess that our feeling was at the time that we didn't think that it was very probable that we would be able to achieve that..

VORZIMMER: Now, that's looking at it from a crew point of view?

ARMSTRONG: Well, from an overall point of view, but...particularly from a crew cycling point of view, it was pressing us very hard to get off of one flight and be available. It took all the people we had, you see, to support -- all the people we had in a flight status were being used. We didn't have any other people and so it was very pressing to us to be able to turn around that fast. It resulted in long training methods..

VORZIMMER: Would that involve any telescoping of the simulators? People backing up to use the simulators?

ARMSTRONG: Yes, we had that problem too. Our overall training, initially, was based on three month centers. The requirements for how many simulators we had, and so on, was based on that and we had to go through an agonizing reappraisal there to find out if we had the equipment and the time to support two month launch centers. And, again, Deke can give you the background in that area because he is the man that obligates crews on times to Washington.

VORZIMMER: But he must have certainly turned around to the crews, though, and said -- he didn't just look at paper schedules and say "Yeah, I can commit my astronauts to two months" without first..

ARMSTRONG: As you know, he and Al (Shepherd) split the responsibility for going on down with the crews to the Cape and spending that month or so with them making sure they were ready to go, and acted as the point of contact for everybody to get to the crew. So he was intimately familiar with the details of what were required in getting ready to fly. So it wasn't just a matter of somebody talking to him; he was talking to people every day, intimately, in the day-to-day requirements of training, simulation, etc.

VORZIMMER: So that your confidence level in Slayton's decision-making was pretty high.

ARMSTRONG: Yeah, he had a lot of information available to him. He was close to the crews.

VORZIMMER: So there wasn't much disgruntled talk when you went to two month launch centers?

ARMSTRONG: Well, when we said that we could make it, we believed it. It just meant that there were certain things we would have to give up in order to convert three months to two months.

VORZIMMER: What type of things were those?

ARMSTRONG: Oh, like how soon a simulator must be ready before a flight. It was a matter of when the equipment would be ready. You had to change it over to get ready for the next flight. It was a matter of how many hours you thought you could get in that piece of equipment. You had to predict some reliability number and some availability number.

VORZIMMER: Did you bump any rock-climbing trips, or stuff like that?

ARMSTRONG: Yeah, we had to cut certain things out of the schedule. For example, we cut parachute training because in order to get ready in two month launch centers, we only had so much time and we had to pick all the most important, and a few things had to go.

VORZIMMER: Do you remember anything else besides the parachuting?

ARMSTRONG: There was simulator time, within certain, so many months of the schedule. It wasn't available as soon, and a number of checkout procedures that we would normally fit in the spacecraft during, went out. The so-called 'wet mock' went out. It went out for other reasons but it reduced our training commitment.

VORZIMMER: How about water egress and things like that?

ARMSTRONG: No, we kept water egress. We thought that was a worthwhile exercise to do in the last month or so before the flight. To go through the procedures. The procedures of getting out of the spacecraft was no problem. You just open the hatches, unhook,

and jump out. That's not the problem. The problem is securing the spacecraft; getting all the systems shut down so that you can proceed to analyze them and look at them after the flight, so that you are protecting all the things you brought back from orbit like scientific components, film, your own records and so on -- getting those put in the spacecraft properly so that they're protected. A matter of going through the proper procedures with the communications systems, so that you can indeed talk to people wherever they happen to be, and so on. Doing these procedures properly is worth the practice and it didn't take much time.

VORZIMMER: Tell me, did they resolve that electrical surge problem? You didn't have that problem in VII?

ARMSTRONG: No, but I'm trying to remember just when..I guess I can't recall..

VORZIMMER: Well, I think that covers it...thank you very much.