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JERRY L. ROSS
INTERVIEWED BY JENNIFER ROSS-NAZZAL
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ROSS-NAZZAL: Today is February 5th, 2004. This oral history with Jerry Ross is being conducted for the Johnson Space Center Oral History Project in Houston, Texas. Jennifer Ross-Nazzal is the interviewer, and she is assisted by Sandra Johnson and Rebecca Wright.

Thanks again for joining us.

ROSS: You guys must be getting tired of seeing me.

ROSS-NAZZAL: No, absolutely not. We always look forward to people coming in.

Let's begin by talking about your Shuttle-Mir mission. How did this mission differ from your other Shuttle missions?

ROSS: The most significant things were, number one, I was going somewhere other than just around the Earth. I was actually going to go visit some other spacecraft. I was going to go visit people that were living in space, and it was my first opportunity to have a direct working relationship with the Russians.

ROSS-NAZZAL: Before you went up there, did you actually learn Russian?

ROSS: They tried to teach me some Russian. It was pretty futile, because I'm not good at languages at all. Plus, we got assigned late enough that we really didn't have that much free time to really concentrate on the language. If we'd had another six months maybe we could have front-loaded the language training and got somewhere with it. But, fortunately, it wasn't that necessary. We had a couple guys on the crew that were halfway reasonable with language, so that helped out.

ROSS-NAZZAL: Did you guys have any challenges on board this mission?

ROSS: You mean during the mission itself?

ROSS-NAZZAL: During the mission itself or during training.

ROSS: No, I think, as I remember it, everything went pretty much as planned. Probably the biggest challenges were just learning how to relate to the Russians and to work with them, and trying to get enough engineering information that would allow us to understand the systems and the performance parameters of the docking module, which we carried into space and mounted to the International Space Station. I think those were probably the most interesting aspects from doing something different.

ROSS-NAZZAL: What were you main goals during this mission, or your assignments?

ROSS: I flew as Mission Specialist number two, the flight engineer for the crew, and I also had pretty much overall responsibilities for the docking module, to understand its systems and to be ready to operate systems or react to things that didn't work quite right.

ROSS-NAZZAL: Were you disappointed that there wasn't an EVA [Extravehicular Activity] on this flight?

ROSS: Of course. [Laughs] That would have been pretty neat to go outside on the Russian Mir station and have a chance to see their hardware up close and personal, especially since it had been in space for quite a long period of time at that point.

ROSS-NAZZAL: During this mission there was actually government furlough. How did that affect your mission?

ROSS: I guess it didn't. The people in the Mission Control Center continued to work. It was maybe a little bit quieter because we didn't have all the other hoopla going on in the background, but from our perspective, it was pretty much transparent.

ROSS-NAZZAL: I have read, though, that there was an unofficial web page for this flight. Do you remember that? It was called the "Utterly Unofficial STS-74 Mission Guide Website."

ROSS: I don't remember that, quite frankly. It probably was a Bill [William S.] McArthur thing, but I'm not sure. [Laughs] I honestly don't remember that. That's a good one. I'll have to go

back and see if I can dig out any information on that one. Obviously, we were pretty intense in our training; getting ready to go fly, I guess.

ROSS-NAZZAL: During this mission you received a number of phone calls from various people, like the United Nations Secretary General, the Russian Prime Minister. Do you remember any of these phone calls and conversations?

ROSS: I remember them. I don't remember much of the detail about it, but I thought it was pretty neat to have that level of importance placed on the mission and what we were doing up there. We did fly a copy of the United Nations treaty, which basically calls all signees, all countries who signed the treaty, to treat any unexpected guests from on high that drop into the country to help with the rescue and good treatment of them. Then after the mission, we took that back to the United Nations and presented it back to them.

ROSS-NAZZAL: Can you tell us about that trip to New York?

ROSS: That was a lot of fun. That was one of the few times I've actually ever spent much time in Manhattan, [New York], and we got to go with the Russians, and we spent most of the day in the United Nations and made some presentations and got a chance to visit with many of the diplomats. It was a very unique experience for us.

We also got a chance to do a bit of touring around New York City, [New York]. I'll never forget one of the places we did go was to the World Trade Center towers. My only time

there. We did go all the way up to the observation deck and look out. So, not too many years later, it was quite a mental feeling to realize what was going on.

ROSS-NAZZAL: Yes, that must have been. What are your other memories about this mission?

ROSS: I remember going to Russia I think at least three times for training sessions on the hardware and inspection of the hardware. I can remember at least one of the times we went when it was really cold. I think it was this trip that we were—no, it was a different trip, an earlier trip to Russia. I was recalling a time when we were at Star City, [Russia], and we were at a big statue outside of one of the facilities and it was real icy, and I slipped and fell and everybody else thought that that was pretty funny. [Laughs]

ROSS-NAZZAL: What was it like training in Russia? How was it different from training at JSC?

ROSS: They're not as interactive with the instructors. Here, the instructors will give us instruction and we'll stop many times and ask questions. We'll have prepared materials ahead of time to study, which we didn't have over there. They really aren't into mass production of workbooks and things like that. In fact, they're somewhat closely held. So it was kind of interesting to see that perspective on things.

We found the instruction to be good. We found it to be relatively rigid at that time. I think it's changed somewhat with the ongoing process of training crews for ISS [International Space Station] now. But it was interesting to see that perspective. They knew their stuff, at least the people that were giving us the instruction on each specific system. I thought it was pretty

fascinating that the docking module had the mating adaptor, the coupling that we used to attach to the Orbiter and to the Mir Station, was designed by a fellow that I had met on my earlier trip over there as part of the Association of Space Explorers trip in, I think it was 1990.

They invited four of us American astronauts to go over and visit in an unofficial manner. It wasn't a state-sponsored visit, and this was while it was still a Communist country, so it was a pretty interesting opportunity. So Dan [Daniel C.] Brandenstein, who was then head of the Astronaut Office, Ron [Ronald J.] Grabe, one of the more senior commanders in the office, Paul [J.] Weitz, who was then the Deputy Center Director, and myself, the Mission Specialist-EVA-type person, got to go over and to tour around. We actually got to go down to Baikonur [Cosmodrome, Kazakhstan] to see a Soyuz launch, back to Star City to experience some of the training facilities there, and we also go to go over to watch at the TsUP [Flight Control Center] during the actual docking. So it was a neat experience and a great opportunity to see the country both before and after the dramatic changes that occurred over there.

ROSS-NAZZAL: After this mission, did you actually go to Russia and do some PR [Public Relations] trips?

ROSS: I don't believe we did go back to Russia after the flight, to my recollection. I've been there other times since then, but for a post-flight type of thing, no.

ROSS-NAZZAL: Do you have any other things you want to say about this mission?

ROSS: I guess it was really neat to be able to go to some place in space, some place where other people were living. Thomas Reiter, a German, was on board with the Russians, and I had met Thomas at the German training facilities when I was there training for the [Spacelab] D-2 mission, so I knew him and it was nice to be able to see him in space.

It was really neat to see a station that had been operating for an extended period of time, to see the interior of it, to see the consequences of not having enough down-mass capability, as we're seeing right now on the International Space Station. The Russians had the capability to take things up to the Station, but they didn't have as much capability to bring them back down. So after a while, the thing started to look like a really tightly packed closet, or some people that didn't ever want to throw anything away. You know, you go to some houses and there's trails through the living room and stuff. That was kind of the feeling we had.

But at the same time, we'd heard all kinds of stories that the Mir Station, because it was old, would smell bad and everything else, and we absolutely did not notice any changes in the odors or smells as we went from the Orbiter on into the Mir Station.

The philosophy they operate under is a little bit different in terms of how they design their hardware and how they operate their hardware. That's not to say it's wrong, it's just different, so that took some getting used to, to understand those philosophy differences and to start to incorporate those into our thought processes, something we did continually from then on as we had crews that lived on Mir for periods of time and then on into the International Space Station Program.

ROSS-NAZZAL: How do you think that this flight prepared you for the next flight, which was a Space Station flight?

ROSS: I think it helped me to start think about leaving things in space, to operate on structures that were considerably above the payload bay of the Orbiter, to think about things that were going to have to be exposed to weightlessness in the environment of space for extended periods of time and what that might mean, because we looked out quite a few windows of the Mir Station and could see where thermal blankets were coming loose or discolored, or there was some micrometeorite debris damage we could see on solar arrays and things like that. So those kinds of things kind of went into my memory bank and helped me to think about those kinds of aspects as we continued to think about how we were going to design and assemble the International Space Station.

ROSS-NAZZAL: Why don't you give us a sense of what the training was like for this next mission and the training you underwent for the EVAs.

ROSS: STS-88 was a very challenging flight, being the first manned mission for the start of the assembly of the International Space Station and it had lots of visibility. We got assigned well in advance of the flight, and because there were several schedule shifts to the right, we continued to train, and we put all that time that we had available to good use. Because it was a first of something, it also put us more in the spotlight in terms of the press exposure and the interviews and things like that, so we had to allocate more time to those types of things.

We also knew that we were going to be setting precedents in many of the things we did, so we tried to be very careful to coordinate what we were doing with subsequent crews to make sure that the way we left the facility after the end of our spacewalks, the way we decided we

were going to do things before the flight, were compatible with and would be a reasonable way for other crews to proceed in the future. That's something you always have to be cognizant of and try to be careful of when you're doing a first of something.

I guess I was fortunate because I had been the EVA Branch Chief for a considerable period of time leading up to assigning crews to Station assembly flights and therefore had my fingerprints all over how we were going to assemble the mission, assemble the various different flights, so I had a pretty good feel for how things were going to be subsequent to our mission, so that worry about that aspect of it was pretty well in mind for me.

The other aspect of Station assembly flights is that they're very, very packed timewise. There's almost no time to breathe, it seems like. Some of my other flights were busy, and in particular, STS-55, the Spacelab mission with the Germans; that was very time-packed.

But the assembly flights are not only time-packed, but everything has to stack on top of each other. It's kind of like building a house of cards. Everything has to build and stay built throughout the duration of the mission and sometimes beyond, so you have to work as a complete crew. Everybody has to do everything right and they have to do it on time, both the rendezvous, the dockings, the capture of the FGB [Functional Energy Block], the Zarya spacecraft, the mating of it, the connections, the spacewalks, the robotics that go along with the spacewalks. Everything has to be very, very carefully choreographed, thought through, backup procedures developed, if you should happen to need them, and everything has to be done on a very timely fashion.

I think that's probably the most telling part of Station assembly flights, and every crew has come back and commented on that and the fact that we keep trying to pack a little bit more into each flight and it gets that much harder to do, because we're really pushing the limits.

Crews come back very tired, and I can tell you that my two assembly flights, I had very, very little time to just enjoy being in space, because every minute was absorbed doing something, and if you weren't busy doing something, you should be.

ROSS-NAZZAL: How do you think that your first flight prepared you for this mission of constructing the Space Station, if at all?

ROSS: I'm not sure that it did that much, because the assembly tasks were a lot different. Certainly some tasks that I did on the EASE [Experimental Assembly of Structures in Extravehicular Activity] and ACCESS [Assembly Concept for Construction of Erectable Space Structure] experiments, especially on the EASE experiment, where you were up at the top and free floating and manipulating fairly large structures around, that helped somewhat because it helped me to learn lessons on how to maintain body position while you're basically holding on with one hand and trying to do work with the other hand.

One of the tasks I did on, I think it was the second spacewalk, where we put the communications antennas on the outside of the Node 1, I literally was hanging on by fingertips with one hand and manipulating this 150-, 200-pound antenna around with the other hand to place it into its on-orbit position. That would not have been something that I would have liked to have seen a spacewalking rookie do, but I felt comfortable with it because I had that amount of experience behind me.

ROSS-NAZZAL: Why don't you tell us about the EVAs for this flight.

ROSS: Three really neat EVAs. When we rendezvoused with the functional cargo block, the Zarya spacecraft, which had been launched a week or so ahead of us, we rendezvoused with it, we had to rendezvous with it with the cameras only, because it was beyond our field of view, with the docking module already placed on top of the external airlock docking ring. We flew down and captured it, with Nancy [J.] Currie grabbing it with the arm and then placing it on top of the Node 1.

One of the things I'll never forget, we had seen a thing happen when we'd put the docking module on STS-74 onto the external airlock. When we tried to rigidize that coupling between the two, the fact that we still had the arm attached to the docking module caused the mechanism not to come together uniformly, and we saw the same thing happen when we tried to put the FGB onto the top of Node 1. I'll never forget, I said, "Nancy, it's the arm that's causing some problems," and we had to open and close it a couple of times, and I said, "Nancy, we're going to have to derigidize or let go of it with the arm."

She said, "I'm not letting go of it now that I've got it." But finally, we talked to the ground and the ground said, "Yes, the arm's the thing that's causing the problems," and they had us derigidize and that allowed us to have enough flexibility to mate the two.

Going out onto the International Space Station for the first series of spacewalks was really cool. I mean, doing something that's the first time was a lot of fun. The first EVAs were primarily to connect up electrical lines that were joining the pressurized mating adaptor to the nodes' connections, and also electrical power connections between the Zarya spacecraft and the U.S. component, the node, because we didn't have any way of providing electrical power to the node once the Orbiter left.

So Jim [James H.] Newman and I went out, and I got onto the end of the arm, and Jim was helping by releasing a lot of bolts and clips that had held the cables in place for launch. We would take off the dust covers, inspect the cables to make sure there weren't any bent pins or contamination in the connectors, mate the connectors, and close them. We did—I don't remember what it was, but it was forty-some connectors in that first spacewalk. It was a pretty busy day.

We did that at both ends of the node and then on up onto the functional cargo block. There were a series of six connections there, which were all power feeds to and from the U.S. element to the Russian side. We also put a slide wire, an EVA tool or aid, on the outside of the node. I should have looked at the details of the flight a little more. I think that was pretty much the first spacewalk.

The second spacewalk, we put two communication antennas on the outside. We put some additional handrails on the outside of the Station because they couldn't be launched in place because they would have been too close to the interior surfaces of the payload bay of the Orbiter. We did a manual deploy of one of the antennas on the FGB that had not properly deployed after it had been launched by the unmanned rocket out of Baikonur. And we did a second one on the third and last spacewalk.

The last spacewalk, we mounted some additional hardware on the outside of the Station for future crews to use. We put a handrail up at the top of the FGB to bridge across a mating adaptor where it had mounted to its rocket for subsequent crews to be able to translate up and down the Russian segment. We deployed that second antenna that didn't come out. Jim Newman put a solar sunshade in front of one of the externally mounted computers on the outside of the node so that it wouldn't get too hot.

What else did we do? We routed some antenna cables that are now hooked up to the U.S. airlock that provide communications to the Russian suits, should we ever use them in that airlock.

I know there must be more, but I can't remember what it is at this point.

ROSS-NAZZAL: That's okay. We can always add those details later. And your third EVA?

ROSS: That was a combination, second and third combination there. The third EVA, we took out a great big bag of stuff. The bag was probably three to four feet on a side, in a cube, and it had all kinds of tools and foot restraints and EVA aids and all kinds of things that are still stowed on the node and have been used, some of them used, and other things have been put in there as a stowage location. So that's still there.

We also did put a couple of what we call gap spanners. They're basically a strap. They kind of look like a cargo strap that we bridge to various different areas on the outside of the Station that we didn't have good translation routes available otherwise. We left some foot restraints on the outside of the Station. We left a couple of tool stanchions attached to the foot restraints.

Basically, we hauled up a lot of stuff on the inside of the Orbiter. We had this tunnel adaptor, which was between the Orbiter's aft flight deck, or middeck, actually, and the airlock, and we could stage a lot of our equipment inside there. So we could take more stuff out with us on each of the spacewalks. We'd have never got everything out otherwise.

ROSS-NAZZAL: I understand that you also tested the SAFER [Simplified Aid for EVA Rescue] units on this flight.

ROSS: Yes. The SAFER unit was something that I had argued very strongly for in the program earlier on. Basically, I saw it as a way for a crew member to self-rescue themselves should they, for whatever reason, become disconnected from the Station or the Orbiter. Up until we started docking to a station, or maybe where we had a space telescope mounted in the payload bay of the Orbiter, the Orbiter always had the capability to fly over and basically scoop up an astronaut should they become disconnected for whatever reason and start drifting away. But I could foresee, with the Orbiter docked to the Station or when crew members were on Station doing a spacewalk when there's no Orbiter around, that for whatever reason, through inattention to detail or a hardware failure or whatever it is, if somebody became free from the Station and started drifting away, basically there's no way for them to recover. I could be just as far as that [gestures] from the table, but if I couldn't reach it, I can't get back.

So I argued quite a while with the program that we needed to have a self-rescue capability, and the final argument was, I said, "Okay, what are you going to tell somebody's spouse, when you could have built this and you didn't, and they're now drifting over the horizon, their battery and oxygen are running out, what are you going to tell them?" And that was the argument that finally convinced them that, yes, they had to spend the money to build this capability.

So basically it was a very small conformal rocket backpack with a hand controller that stowed down here on the hip of the suit [gestures]. It's normally dormant, but if you ever did need it, you can reach down, deploy the handle, activate the system, and through a little joystick

capability, then you can control your attitude and then do translations to get yourself back to Station or the Orbiter and reattach yourself.

That had been tested by Carl [J.] Meade and Mark [C.] Lee on an earlier flight in a prototype version, but our flight was, I think, the first flight where it actually flew as an operational capability. But I had argued with the program again—it seems like I argue a lot—I encouraged the program again to validate the changes that had been incorporated into the operational version of the SAFER unit. They had changed software, they had changed components. They had basically changed almost everything, and even though from the exterior it looked basically identical, it was considerably different.

After some management changes in the program shortly before we flew, I was able to finally convince the program that we ought to do a very minimal flight test to validate if the thing actually works as we wanted it to.

So at the end of the third spacewalk, we basically flipped a coin and Jim Newman said, "Okay, you can do it." So we went into the payload bay and Jim held onto my safety tether, but he gave me enough slack so that it wasn't making any inputs into my physical motion. I activated the SAFER unit and started to do a very brief flight test around the payload bay, and very quickly we found out that it wasn't working as we expected it to. The primary thing was that the instrumentation didn't have it work right and part of the hand-control system wasn't implemented the way it probably should have been. So after discovering those two things, we completed the test flight, came back into the airlock, and finally, that was the end of the third EVA on the flight. It was a bittersweet kind of a thing. We successfully completed everything we wanted to do, but at the same time, we were completing the EVAs and getting close to the end of the mission.

ROSS-NAZZAL: You had done some work on the MMU [Manned Maneuvering Unit]. How [does] the SAFER unit differ from the MMU?

ROSS: The MMU is a Mack truck; the SAFER unit is a minivan. The MMU was designed to be able to transport a crew member and maybe some equipment to and from and over fairly large gaps. It had a delta-V or a change in velocity capability of around forty foot per second is what I remember, and it may have been more than that. But it was more the size of a pretty good-sized TV set mounted on your back, and it took a lot of support hardware to do that. It was launched in the payload bay of the Orbiter, and it was pretty heavy equipment.

The SAFER is more like a little parachute that you strapped to your back. It's not very big, it's not very heavy, and it's very conformal to the outside of our primary life support system, that big box that's on the back of our suits. So it's just two little towers along the sides and then a thing that goes across the bottom, which is where the pressurized nitrogen is at. And it has a capability of no more than about ten-foot-per-second change of velocity. So it basically is a little motor scooter, a little capability, what we determined to be the absolute minimum capability we thought we needed to be able to rescue ourselves.

ROSS-NAZZAL: So the technology for SAFER was based on MMU technology.

ROSS: In part it was. In part it was. The MMU had two hand controllers, one for translations, one for rotations. The SAFER's got one hand controller and a switch to change between rotation and translation. It has a little stabilizing gyro on it so that you can stop your attitude excursions,

a tumble, if you will. And it does have one-pound thrusters that allow you to push yourself back toward the Station.

ROSS-NAZZAL: On this flight there were also two satellites that were launched. What role did you play in that?

ROSS: I was a photographer on both of those satellites that were launched. I think Rick [Frederick W.] Sturckow launched both the satellites, if I remember correctly. One of them was for the Air Force. It was a technology demonstration satellite that had several different pretty unique experiments in it. I don't remember a whole lot of the details now. The other one was for the country of Argentina, and it was, again, some technologies that they were trying to develop a stronger in-country space capability. I remember one of them was designed to track whales, I think, and I forget what the others were for, but there were about three or four experiments they had in those also. Both of the satellites stayed in orbit for a period of, I think, about six months or so after we released them.

ROSS-NAZZAL: Are there any interesting anecdotes or stories from that mission that you recall?

ROSS: Now you're putting me on the spot. I should have done my homework on this a little more. No. What do you have in mind?

ROSS-NAZZAL: I didn't have anything. Surprisingly, your later missions there's not as much detail as there are on the earlier missions.

ROSS: Yes, it became more ho-hum, I guess, and there's less detail, and closer together in some cases.

No, I think it was pretty much a businesslike flight. I guess, yes, there is one thing. We had a press interview on orbit and all of us were cuddled up in the node, FGB, FGB area, I guess it was. And at the end of the press conference, I pulled Rick Sturckow's head over to me and I kissed his forehead, and he says, "Aw, all my Marine buddies are going to see that."

I said, "I was just trying to get into the spirit of international cooperation and friendship."

Another neat thing we did is the Node 1, when we left it, or when we got up there and also when we left, it was basically wide open. There wasn't much in there. It doesn't look like that anymore; there's a lot of stuff stowed in there. But we took Nancy Currie and we put her right out in the middle and stopped all her motions and then released her and then let her try to see if she could get her way to some surface. It kind of looked like a cat trying to swim in water or something. It was pretty cool. So that was pretty neat, yes.

ROSS-NAZZAL: Sounds like a fun flight.

ROSS: Yes. The other interesting aspect was that we had Sergei [K.] Krikalev that was added to the crew relatively late, and that added another unique dimension to the flight. I'd flown with internationals before, but having Sergei, with the wealth of experience he had on the Mir Station, it was really good to have him there to help with the hardware and to work through any difficulties we had with that.

I'll never forget, he went into the FGB and he just said, "Something's wrong."

We said, "How do you know?"

He said, "Something doesn't sound right." And, sure enough, there was a piece of plastic that had been left in one of the air ducts in the system that he just knew wasn't sounding right. So he kind of dug in a little bit and found it and pulled it out and fixed that problem.

Having Sergei on the crew made dealing with the Russians a lot easier, because prior to his being added, I had tried on a couple of different occasions to get additional information provided to us on maintenance activities for things inside of the FGB, and also to get additional information on how we could manually assist anything that didn't work right on the outside when we were on our spacewalks. Of course, the Russians were reluctant to tell us anything and basically would tell us, "Nothing will go wrong. It will all work right."

So we had to deploy two antennas on the outside that didn't come out, and we also had to change out a battery-charging controller that had died in between the time that it was launched and the time that we launched. Again, having Sergei on the crew helped to facilitate both of those and made the working relationships a lot easier.

The other thing that was kind of interesting about this flight was at one point, we weren't going to go inside the Station; we were just going to hook things together and that was going to be it. Then they said, "Maybe we'll have you go in the node to do some things."

I said, "I think we ought to go in the FGB, too." [Laughs] So we finally convinced them that we ought to go into all the things and open everything up and check everything out and do some maintenance on things. So that was pretty neat. Initially, we wouldn't go into the Station at all and then, finally, we got to go in the whole thing. So we got to be the first crew to be inside the Station.

ROSS-NAZZAL: Fun, yes. Let me ask you about your next flight. The next flight, seven missions. Basically, you're a record holder and you beat out John [W.] Young, you beat out yourself, Story Musgrave, other people. What were you thinking when you were assigned to a seventh flight? Did you actually think you might be assigned?

ROSS: There was a concern in the Astronaut Office that as long lived as when John Young got his sixth flight, that probably nobody would ever be able to go beyond six. You said that I surpassed John Young. I will never surpass John Young no matter what I do in my life. John is my hero, and he has done so many incredible things for this country with our program, that I don't think anybody could ever surpass what he's done.

Susy Young will tell you that John also has seven launches, one of them just happens to be from the surface of the Moon.

ROSS-NAZZAL: That's one way of looking at it, yes.

ROSS: I would trade several of mine for one of those. [Laughs]

ROSS-NAZZAL: Stick around long enough, you know.

ROSS: I think that's probably not in the cards, but we'll see.

It certainly was an honor and I still consider it a good start. I would like to do eight, nine, ten, whatever. I just see it as being a fact that I've been willing to stick around and work hard and continue to be excited about what I'm doing, and I think Franklin [R.] Chang[-Diaz] would

tell you the same thing, when you talk to him, that we love what we do and we feel very excited about the opportunities we've had.

The fact that we're the first two to ever fly seven times is neat, but I hope it doesn't last very long, because if it lasts long, that means that we aren't progressing the way that we want to progress. So I think my record for the number of U.S. spacewalks and time outside I hope get eclipsed very soon, and I hope that somebody goes well beyond my record of seven flights. I mean, it's nice personal things to have, but for the country and for mankind, if they aren't wiped out and exceeded, then we're not doing the right thing.

ROSS-NAZZAL: What did the media think? Did the media cover this at all?

ROSS: They had some excitement about it, but it wasn't that big a deal. It actually was probably less than I expected it to be, frankly, but that's fine with me. It didn't disappoint me at all. I think my crewmates had more fun with it than anybody. They kept asking me, they said, "What was it really like back in Mercury? Did you have to arm wrestle with 'Ham' to see who was going to get the first flight? Is that the way that they did it in Gemini, Jerry?" They kept giving me a lot of bad times. Basically, I'd just tell them that they were jealous, but, you know. [Laughs]

ROSS-NAZZAL: You've given us some insight into your crew relationship. Can you give us a little more insight into the relationship between this crew?

ROSS: Yes, this was really a good crew. We had a lot of fun together. The people that had flown in space before, Mike [Michael J.] Bloomfield, Ellen Ochoa, and Steve [Steven L.] Smith, were all exceptionally talented folks. They knew their business inside out and did a great job at it. We had three rookies, Steve [Steven N.] Frick, the pilot, Lee [M. E.] Morin, and Rex [J.] Walheim, who are spacewalking buddies with Steve Smith and myself, and, again, they just added a lot to the flight and a lot of exceptional talents. They didn't operate as rookies.

So we had a very challenging flight, being the first flight of the last phase of the assembly of the Station and the first of the truss elements to go up, big truss elements, if you exclude Z-1. It was, again, another kind of a step up in what we were doing, and we felt, again, some of the pressure doing four spacewalks on this flight and having two teams of two each going outside.

It was kind of neat that Lee and I got teamed together, being the two gray-haired spacewalking grandfathers. That was pretty cool. I'm glad they called us the Silver Team instead of the Gray Team. That was nice of them. [Laughs]

ROSS-NAZZAL: Do you remember who came up with that title?

ROSS: I think Steve Smith did. Yes, I think he called us the Silver Team.

ROSS-NAZZAL: And you liked that title?

ROSS: It was fun, yes. Anytime that you have a handle like that or some unique thing, then the press tends to capture that and run with it, so, yes, it was kind of fun. Of course, I got a lot of

ribbing from my friends back home. "Oh, the Silver Team." I said I'd rather be doing that than working for a living, so, yes.

ROSS-NAZZAL: Why don't you tell us about going up to the Station. You had been there for the first assembly mission and now you're going back. What was it like coming up to the Station?

ROSS: I was really looking forward to it, because when I left, it was just a very small part, and now you had solar arrays and a service module and a lab and everything else up there. Also, we were going to do our spacewalks out of the Station's airlock as opposed to the Shuttle's airlock as I'd done on all the others, so for all those reasons, I was really excited about it. Plus, putting the truss on there and being able to go out a considerable distance from the edges of the Orbiter's payload bay I thought was going to be really cool, and it ended up being exactly that. It was really neat.

Also the fact that we had the little railroad-track car, the Mobile Transporter, on there was another neat thing that was a first, and it was neat to be able to be part of that also. But also I think the fact that we had crew members up there that were operating, they were doing science, which is what the Station was built for, and we were taking up new science experiments for them to conduct, and bringing home some of the results from some of the previous science experiments, all said that the things that we dreamed about and worked hard for for a long period of time were actually starting to happen.

So for all those reasons and the fact that just getting to go fly in space again, all those things that made it very rewarding, and seeing the Station as we started to see it for the first time, you go, "Wow. That's starting to get big." It was pretty neat.

I really would really love to go do one more at the end of the assembly sequence to see the whole thing, you know, be there at the start and then in the middle and then be at the end, but I'm afraid somebody else's is going to have to show me pictures of that one. [Laughs]

ROSS-NAZZAL: Are you hoping for an eighth flight?

ROSS: I think hope against hope, because I don't think it's going to happen. I think before the *Columbia* accident there may have been an extremely remote opportunity, but with the down period, the lesser flights, less frequent flights, I just don't see it happening, unfortunately. But I'm going to count my blessings. I've had a lot of fun. It's been a long time, and not too many people can have this much fun and not have to work for a living.

ROSS-NAZZAL: Why don't you tell us about any interesting anecdotes or stories from this flight or about the EVAs.

ROSS: I think one of the things that got my attention was the fact that when you go out onto the truss and you're outside the payload bay limits, it's a long ways down. And when you come out of the airlock the first time, your face is pointed straight down at the Earth and it's about 240 miles down; there's nothing between you and the cloud. That's pretty impressive.

But getting out onto the structure of the truss and maneuvering around out there is a neat feeling, and when the entire truss is built, that's just going to be awesome, because you're going to be out there 180 feet away from the Orbiter, looking back, and there's going to be nothing below you. It's pretty incredible.

I can remember at the beginning of my last spacewalk, I think it was, they asked me to go out and close a thermal flap that hadn't been completely closed on an earlier spacewalk. They asked me to do that at night while we were getting ready to do some other things. So I kind of had to go along in the middle of the dark pass and find my way over there, and then after I'd completed the task, get back to where I'd started from. I mean, it wasn't eerie or anything; I just thought it was pretty cool. It was something I was doing that I hadn't planned to do and it was along a translation path that was not preplanned, but I was able to find my way there in straightforward fashion and get back, so it was pretty cool.

The other impression I had was at the beginning of the last spacewalk, we had to deploy the airlock spur. It was a long beamlike thing that was along the starboard edge of the S-Zero Truss, and it was hinged down at the bottom. We had to remove bolts to free up and swing it around and put it over so that it would provide a solid translation path from the S-Zero Truss over to the airlock area. They had pre-positioned the foot restraint on the end of the arm out there at the edge of the S-Zero Truss, and I had to maneuver my way along the backside of the truss and get out there and get into the foot restraint, at night, and there was very little to hold onto. And when you get out there, I mean, it's just pitch dark and you're going, "Okay, where's the foot restraint at?" Then kind of holding on a little bit and trying to fish around with your feet to find the foot restraint and get into it, and I'm going, "Wow. This is cool." [Laughs]

One other, and one of the most lasting things I'll ever remember about the spacewalks, was at the end of the last spacewalk. I was on the end of the Station arm and I was over on the port side of the Station, just having completed some work, and they had to maneuver me all the way around and get me back over to the hatch at the airlock, which is on the starboard side. So I had probably a thirty- or forty-minute ride to just hang on.

As we started that, we were coming over the Mediterranean Sea, and it was going from day to dark, and I can remember watching the colors of sunset glancing off of the Russian part of the Station and the U.S. part of the Station, and then I can remember starting to see the city lights that lined the Mediterranean. And then as we got a little bit further over to the east, I could start to see some thunderstorms blossoming down there at the eastern edge of the Mediterranean, and then I could start to see the moonrise. At that point, the stars were above and the Earth was below, the city lights, and as they started manipulating me around, sometimes the stars were down there and the Earth and city lights were up there. Just incredible sights. I continued to watch the thunderstorms as we went across.

Then I came over past the tail of the Orbiter and I could look into the payload bay and all that, and kind of just taking my time, looking around. Then they brought me around over to the starboard side, over towards the airlock at about sunrise, so I could see the colors on the solar arrays and on the truss and on the various different pressurized modules as the sun came up and got real bright. That's something that will just always be there. If that's going to be my last spacewalk memories, that's pretty good ones.

I can remember, also, on the first—no, it was probably the second spacewalk, again—Lee Morin and I were outside and we were relatively early in the spacewalk, and I can remember saying to "Woody" [Sherwood C.] Spring on the end of my second spacewalk, on 61-B, we were talking about how neat it was to do the construction tasks and stuff, and I said, "Yeah, Woody, let's go build a Space Station."

So I recalled that to Lee while we were outside and he said, "Yeah, they ought to pay us lots of money."

I said, "Lee, we ought to pay them a lot of money for this experience." [Laughs] Something to that effect.

But as a result of our high-wire acts both on 61-B and on 110, the crews were given honorary Ironworker credentials. [Laughs] I actually went out and did a presentation to the Ironworkers out in Las Vegas [Nevada], I think it was, in one of their national conventions. I think it's kind of interesting, because I worked in steel mills in Gary [Indiana] during my summers going through college, so that was kind of a neat way to close that loop.

ROSS-NAZZAL: Did you talk to them about that in your presentation?

ROSS: Yes, you bet. I guess the thing I like to think about the most on the spacewalks is the fact that I had been in the design philosophy and the hardware development of the Station ever since day one, and to be out there and actually helping to do the hands-on assembly of something that you had helped in some cases conceive of, like the CETA [Crew and Equipment Translation Aid] carts and all the other things that we had developed, we'd get prototypes of the hardware into the water tank, test them, make recommendations, get things modified, bring them back and test them again to where we thought they were an acceptable way to do business. To have gone through that entire process and get the hardware, the actual hardware, on orbit and see it work and see it come together basically without any hiccups, pretty rewarding. It's kind of a nice way to turn out the light on a career, if that's the way it's going to be, because you get to see something from start to finish so seldom in a career, and to have that kind of a capability or experience is pretty cool.

ROSS-NAZZAL: Yes, you've definitely had a significant impact on that development of that program.

I'd like to shift gears a little bit and talk about *Columbia*.

ROSS: Okay.

ROSS-NAZZAL: Where were you when the *Columbia* accident occurred?

ROSS: After my seventh flight, I was assigned as the Chief of the Vehicle Integration Test Office, and as such, one of my responsibilities is the operation of the astronaut crew quarters at the Kennedy Space Center [Florida]. Along with that then goes the responsibility for being down there and doing various different functions for launches and landings as well as TCDTs [Terminal Countdown Demonstration Tests], dry countdowns.

So I was down at the end of the runway waiting for the crew, and I had Bob [Robert D.] Cabana down there with me, head of the Flight Crew Operations Directorate, and Bob was relatively new in the job and I was getting a chance to show him around, show him some new facilities. I'd taken him into the convoy commander's new vehicle and got him a little bit of a tour of it as we were waiting.

I'll never forget, we had just left the vehicle and were outside, and shortly after we got back outside, some of the guys in the convoy commander's vehicle were pounding on the windows—it looks like a big RV [Recreational Vehicle], is what it looks like—and waving for us. We thought maybe one of us left our cell phone or something. We couldn't understand why they wanted us.

So we went back in there, and they told us that they had lost communication with the Orbiter, and I thought, well, that's not that big a deal. That happens.

Then they said they'd lost data, and I said, "That also happens. If you lose com [communication], you're probably going to lose data." And shortly thereafter, they said they'd lost tracking.

At that point, I told Bob I was going to get the family headed towards crew quarters, and he said, "Yes, I agree." So I went outside of the—you're going to have to see the other tape and see if I get this all right or not—I went outside of the vehicle, said a quick, quiet prayer to myself and for the crew and families, and then got on the cell phone, called the family escorts, told them that "We think we've lost the vehicle. Get the families rounded up and ship them back to crew quarters."

Then I called my folks back at the crew quarters, Judy [Judith] Hooper and Lauren [L.] Lunde, and told them that we think we've lost the vehicle, to secure the facility, and get the security police out there, turn off the TVs, tell the ladies we're going to need food for the families and things like that.

Then I rounded up the flight surgeons that were out there with us. There were several astronauts out there with us. We had all got onto the crew van, the Astrovan, and beat feet back to the crew quarters, and we did beat the families back there. By the time we got back there, they had already started to show the break-up sequence and the fireballs going across the sky [on TV].

I got into the office, made one or two phone calls, and then the family had arrived, and I went out and met the family at the top of the elevators as they came into the astronaut crew quarters, and escorted Evelyn [Husband] and her two kids down to the conference room, where

we put them. Basically I was telling them we didn't know anything yet, even though we had a pretty good idea at that point.

Then shortly after Bob had more confirmation, after talking to Mission Control Center back here, I went down with him when he informed the families that the accident had occurred and the likelihood that anybody would have survived was not very realistic. At that point the room just broke up with everybody crying and hugging.

So I did what I could for the families, made sure that each of the families had somebody helping them, and then I went back down to my office and started making phone calls to arrange for airplanes to transport the families back home, make sure that the people back here were starting to set up security and transportation and all that kind of stuff.

Then I learned that the families had not packed up their belongings; they'd left them down in their facilities where they were staying, down on Cocoa Beach, [Florida]. So I rounded up some more of my folks and shipped them off with orders to go pack everything up and to turn in any rental cars or anything like that.

Meanwhile, I got three airplanes, two of ours and one from KSC [Kennedy Space Center], that we had to meet up at the skid strip down at the Air Force side of Kennedy, and helped facilitate the Administrator [Sean O'Keefe] when he came up to the quarters. He had some phone calls that he had to make. We were also arranging for a telecon [teleconference] from the White House, from the President [George W. Bush].

So all that finally came together and we had the crew's bags packed up, and we delivered them out to the skid strip. I had manifests pulled together for each of the airplanes so we knew which airplane to put whose bags onto. We got food out to the airplanes so they'd have things to eat. We arranged the manifests so that we had a medical person on each airplane, and we also

had an astronaut, a blue-suiter, with each of the families to help with anything that they needed during the trip.

I had saved a seat on one of the airplanes for me, hoping that I was going to get to go home, but then I found out that they had activated the Rapid Response Team that I was a member of, and so I didn't get to come home. After I got the families off on the airplane was a time that I had a chance to sit quietly for a while and to be by myself. And after I got straightened up again, then I went back and talked to my family back here in Houston and had to inform them I wasn't coming home, which isn't exactly what they wanted to hear.

Then I had to go back and pull all my dirty clothes out of the wash that had not got washed yet, and try to pack a bag to be deployed to Barksdale Air Force Base up in Louisiana, Shreveport. I met an Air Force C-141 airplane out at the Shuttle Landing Facility later that evening, and we had probably, I don't know, about forty people from KSC on the airplane. Mike [D.] Leinbach was the leader of the team.

We flew up to Shreveport, and folks had already arrived up there from here. Once we got to Shreveport, they took us over to a hangarlike facility where they gave us information on where we were going to be staying, and then loaded us up in buses to take us over to get rental cars in the middle of the night. I think I finally got to bed about midnight or so, after having got up about three o'clock in the morning or so for the weather briefing for the pilot, who was Kent [V.] Rominger, who was flying the STA [Shuttle Training Aircraft] down at the Cape [Canaveral, Florida]. So it was a pretty long day, and the bed felt pretty good that night.

The next day, I was assigned a team of KSC technical experts, and Ed Mango also was given a team, and he and I drove down to Lufkin [Texas], and the intent was to work with the folks down in the Lufkin area to do searches of the school grounds in the area that had had debris

or potentially had debris on their grounds to make sure there was nothing hazardous on the school grounds, that being Sunday at that point, so that the school could open on Monday and they wouldn't have any concerns about hazards for the kids.

Once I got my team down there and had coordinated with them and turned them loose, then I started working to find out what else I could do. Eventually, I decided that I would take an NTSB [National Transportation Safety Board] ballistics expert, trajectory expert, who had come along with us, over to look at some reported holes in the ground at Fort Polk, Louisiana. So we got a Texas National Guard helicopter to take us from Lufkin over to Fort Polk, Louisiana, and the folks met us over there and they took us out into the weeds and showed us two of the three holes that they had found so far at that point.

The first one that they took us to was an incredible hole. I mean, the hole was probably, I don't know, eight, ten feet in diameter and probably six, eight feet deep, and you could see sand or dirt that had blown up from this hole on the trunks of trees that were surrounding the hole that were fifteen feet or more in the air. I could see a little chunk of metal sticking out of the water that had already started to fill the hole, and from what I could see, I thought it was probably part of the fuel feed lines going into the pumps for one of the Shuttle's main engines, or part of going from the pump into the main engine head itself, and that's what it turned out to be.

Then they showed us another one before it got too dark and we couldn't do any more searching that night. Those ended up being two of the pieces of hardware that went the furthest to the east, being the densest pieces of hardware that came off the vehicle.

The helicopter then took us back to Barksdale Air Force Base again for the night. The next day, then, Dom [Dominic L. P.] Gorie and myself, from the Astronaut Office, were deployed back to Lufkin to start setting up the search for the debris. Dom was the head of the

safety group for the Astronaut Office, and as such, he was on the Mishap Investigation Team, so the two of us got directed to go down there.

The rest of the team that had gone to Shreveport eventually did join us at Lufkin, probably about a month later, I guess. But Dom and I had our hands full from then on for the next three months, basically. We were charged with leading the air, ground, and water searches for the debris, and it took us probably about a week to get our arms around what we were doing and set procedures in place and start to get the resources to do the work.

Then after about a month, things kind of settled out and it was basically just tending shop and encouraging folks and trying to keep things on the tracks after that.

I think for about the first month, basically, both of us were there, and after that, we started trading off, give each other a little bit of a break, but I can literally remember going out at midnight to wash some underwear so I could go to work the next day. We were working like five o'clock in the morning to ten o'clock at night or later. You do that for a period of time and it kind of wears you down, but we were doing some pretty important stuff and time was of the essence.

Of course, one of the concerns was any harm that we might cause to the populace up there, because we had a probability that we had unexploded explosives, that we had possibility of fuel tanks and things that still might have hazardous chemicals in them, and we found several of those. So it was very important what we did, and, fortunately, nobody got harmed, other than the occasional spider bite or a snakebite. I think we had one person that had a heart attack and maybe another one, and then, of course, the two people that died in the helicopter accident. We still correspond with those people.

ROSS-NAZZAL: You were one of the few astronauts that was in the office during *Challenger* and then again during *Columbia*.

ROSS: Yes.

ROSS-NAZZAL: Can you give us a sense of how different this accident was? What sort of impact did this accident have on the astronaut corps versus the *Challenger* accident? Were there similarities? Were there differences?

ROSS: There's, obviously, some of each. I think the similarities are the frustrations that we feel, because the hardware was trying to tell us something, and for whatever reason, we weren't smart enough or diligent enough to hear it. In both cases, at least I didn't know what the hardware had been trying to tell us. I didn't know that a big chunk had come off on STS-112, and I think there was a large part of the office that didn't. Certainly, I think there were very few people in the office that knew anything about the O-ring being damaged by heat getting through the seals on the solid rocket motors before *Challenger*. So there's a certain level of frustration in both cases, because they could have been prevented had we been smarter, more diligent, whatever.

I think in the case of the *Challenger* accident, it happened so early in the Shuttle Program that it didn't hurt quite so much, and I know that sounds hard to say or hard to believe, but somehow I think a lot of people would expect that early on in the flights of a new program, that you might have an accident. And the fact that the accident occurred during launch, which is where most people think an accident would occur, also kind of somehow makes it a little bit easier to accept.

We had gone along for so long, since *Challenger*, with a good record of safety and successful flights, and we'd never had any problems or even really considered that we'd have problems during entry. To have a crew that had a great time on orbit, done some really great science, and were sixteen minutes away from touchdown, to lose them like that was really tough. It's also tough from the perspective that we're in the middle of building the International Space Station and have that additional consideration. I guess that's the significant things.

For me personally, I didn't get a chance to work at all on the recovery from *Challenger*, other than some minor things here and there, so this time, being given the opportunity to be right in the mix of things and trying to contribute was a good feeling for me.

Last time, on *Challenger*, I went to a lot of memorial services, graveside services, those types of things, and, frankly, I've not made any of those this time. I did several different types of appearances, talks, dedications, up in East Texas while I was up there, but I didn't do any of the official crew things at all this time, because I was never around. So I've seen both sides of that story, I guess.

ROSS-NAZZAL: That must be very difficult.

ROSS: It is, and I think everybody in the program, especially this time, feels some degree of responsibility, that couldn't we have thought of something, been smarter, worked harder, been more diligent, to somehow preclude it from happening. So I think everybody feels some level of responsibility this time around, and to lose good friends is very difficult to do, and especially when you might have some part to play in it.

This crew, the *Columbia* crew, was really a neat crew. They were really nice people. I was pretty close to several of them, as I was for some of the *Challenger* guys. I had flown to the Cape with them on an STA, or business jet, going down for launch. Dave [David M.] Brown and Mike [Michael P.] Anderson had worked for me, and I had helped get them assigned to this flight, and they were thrilled to be assigned. So there were a lot of close relationships there. I was with the crew when they were suiting up for launch, rode out to the LCC [Launch Control Center], where I got off and they went on out to the pad, and then to be waiting for them at the end of the runway.

ROSS-NAZZAL: A year has passed since the *Columbia* accident. Did you have a chance to go back up to Lufkin for the February 1st memorials or to Nacogdoches [Texas]?

ROSS: I went up Hemphill [Texas] in, I think it was December to do a presentation up there at the VFW [Veterans of Foreign Wars] hall. I had personal family friends down here over that weekend, and I had been requested to do the one in Lufkin, but I had to decline it because I had friends here. That was the only weekend they were here, so I could hardly leave to go do that.

ROSS-NAZZAL: Did you have a chance to see the Super Bowl?

ROSS: Yes, I did watch the Super Bowl.

ROSS-NAZZAL: What did you think of the NASA—

ROSS: I thought they did a very nice job on that, as opposed to some other things.

ROSS-NAZZAL: We won't talk about that. [Laughter]

Once the recovery wrapped up, what have your duties been since that point?

ROSS: I've come back to my regular job as the head of the Vehicle Integration Test Office. We're, obviously, relooking at how we do everything. I've changed the tasking of some of my engineers that work at the Cape, who are the ones that follow the Shuttle processing. In the past, they've only followed, basically, the Orbiter until everything was stacked together, and then they would start to follow the entire stack as it progressed towards the pad and launch. I've changed their tasking so that they now have the broader requirement to look at the SRBs [Solid Rocket Boosters], the external tanks, the motors, every aspect of the processing of all the components up to and through launch, with the express purpose of trying to see if there's any information that's out there that isn't getting back properly to our office. I'm looking for any telltale signs, like soot between O-rings or a chunk that came off the external tank and put a ding into one of the solid rocket motors, that we might be able to get wider distribution of the knowledge so that we're more knowledgeable, can ask more intelligent, harder, more timely questions.

Basically, my entire team, I'm challenging them and making them be more doubting, to ask more frequent, harder questions. Don't accept an answer without getting some validation that we really believe it's true, and I think the entire Astronaut Office is taking some of that approach also, that we're becoming more Missourians in that they've got to show us, they've got to prove it. We can't assume that everybody that says they're an expert, is an expert. And even

if they are the expert, if they're a good enough expert. So those are the kinds of things we're looking at.

Beyond that, we're looking at all of our procedures. We've refined checklists where we had checklists. We built checklists in some cases where they were just the standard way of doing business, but didn't have a formal checklist in place. I'll be reviewing for the final time our inputs into a Contingency Action Plan that's how we would respond to accidents in the future.

One of the things was we didn't have a Contingency Action Plan for a landing emergency. We had them for ascent emergencies, but not for landing emergencies, so basically everything I did at the Cape on the day of the accident was things as they were written for a launch accident, but as I saw the need to modify them for where we were at. And where I think we did a much better job for the *Columbia* crew in response to the accident than *Challenger*, I think there's always room for improvement.

So we're going through all that. There's other paperwork kind of things we're cleaning up. We continue to monitor all the Station activity. I've got a series of engineers down at the Cape that are responsible for doing all the fit checks and sharp-edge inspections and crew-equipment interface tests and on-orbit constraints tests and multiple-element integrated tests, all those things. They're down there day in and day out, doing those and coordinate with the crews to get them down there to get the hands-on experience with the flight hardware.

I also have folks that have worked in Italy and Germany and Japan and Canada and a little bit in Russia still yet, so we're continuing to do all the hardware processing and get all the hardware ready to launch once the Orbiter's ready.

So we're staying pretty busy, and I've kind of got the time line such that we'll complete all those other things by the end of March, such that we could pick up with the normal template

to support a launch in September starting in April. If the September date slips out, which it most likely will at this point, then we're going to have to scratch our heads a little bit on exactly what we're going to be doing for a short period of time, hopefully.

ROSS-NAZZAL: Let me ask you about some of your EVA assignments. I want to make sure that we cover all this. In our first interview, you talked about your work with the NBL [Neutral Buoyancy Laboratory]. Can you talk to us a little bit about your work to encourage NASA to design and to build the NBL here?

ROSS: After 61-B EVAs, where we did the EVA construction experiments, it became very obvious to us that the water tank we had over there in Building 29 was not going to be adequate for doing a Space Station, if that's what we were really going to build. Literally, the hardware that we assembled in the Building 29 water tank was sticking up above the surface of the water in many of the instances of what we were doing.

So we took pictures of all that and when we came back and did our debriefings from the flight, Neil [B.] Hutchinson, who was, I think, then the Space Station Program Manager or Project Manager or whatever his title was, had been fairly recently put into that position from being a Flight Director. We told him that, and he listened to it, so he supported us forming a team of EVA experts and putting together a briefing package to go to [NASA] Headquarters [Washington, D.C.], after we'd gone through the various different checks and balances here on site, to go to Headquarters to make our pitch for getting monies to build a larger water tank down here, and we were looking for construction of funds facilities to do that, COF. And, literally, I ended up being the pitchman most of the time for those presentations, and I was going to

Washington once or twice a year to various different review boards to make those presentations. A couple of times we were on the list of things to be funded and got very close to actually starting to dig holes. Then something would happen; the Station program would get delayed or we went from Freedom to ISS, and the program was put on hold.

Then Judd Pearson, who was head of Code M for a while, had put me in charge of another team that was going to look at how we could build a bare-bones version of this water tank that would have been down there fairly close to where the nursery is, the childcare center, down there, right next to where the X-37 or whatever it was being built. And it would have been more of a tent city, with a hole in the ground, and it would not have been a very good way to do business, but he was trying to find some way. Everybody agreed that we needed the facility to build the Station and train for doing it, but they were having a tough time finding the money and how to do it.

In the transition from the Freedom Program to the ISS, there was a lot of contractual rearrangement going on, and McDonnell Douglas [Corporation], who had the facility out here where the Sonny Carter [Training] Facility is now, that facility was going to be excess as part of the termination of the Freedom part of the contracts. I don't know exactly how things came about, but as part of that termination of that program, it was agreed that McDonnell Douglas would build in their facility a water tank to our specifications. Then when the facility was turned over to us, we would take over ownership of the tank in the facility. They could do it quicker, they could do it cheaper, and we'd have the facility when we got done.

So as I was preparing for one of my flights—I think it must have been STS-74—was when that was coming about, so I helped with putting together the design package, reviewing it, and making sure it's what we thought we wanted. Then for a year or so, they went off and built

it. Then when I came back from that flight and was again the EVA Branch Chief of the office, that's when I was asked to chair the Operational Readiness Inspection Team that would certify that the facility was ready for us to use and therefore we were ready to accept the facility from McDonnell Douglas. So there was probably a six-month to a nine-month effort to review the facility, certify all of its design and operational capabilities, and then eventually to recommend to the contracting officer that we accept it from McDonnell Douglas.

As part of that process, as we got very close to the end, I very distinctly remember putting on scuba gear and swimming around the entire tank. The tank is 200 feet long and 100 feet wide and 40 feet deep, and I swam around the perimeter of the walls of the tank at three different levels to do an inspection of it, because we were having some seepage of water through the concrete and I wanted to make sure that we weren't buying a problem. I convinced myself, and it's since proved out, that everything was fine. It was just part of the curing process of the concrete after you put water in it. But I swam all the way around it at three different levels, and then I zigzagged up and down along the floor of the pool. By the time I got out of there, I was pooped. That's a big facility to do that much swimming. It was exhausting.

Then I was also given the honor of being the first suited astronaut to go in the tank after it was certified for operational use, and that was pretty cool, again, to be involved with something from day one, identify the need for it, and be basically put in charge of making it operationally ready, and then given a chance to go use it. Then we used it to train the Hubble [Space Telescope] guys on their repair mission, and then we used it for STS-88 and 110, as have all the other subsequent crews to that. It's a great facility. I can't imagine how we would have built the Station without it, frankly.

ROSS-NAZZAL: Let me take you back and ask if you can give us a sense of the kind of pitches you would give to people at Headquarters. Obviously, you told them that the equipment for Station wasn't going to fit, but were there other examples that you gave? For instance, you mentioned that they did Hubble repairs in that pool.

ROSS: Yes, we tried to look at other programs that were potentially out there that they might be able to also use the facility for, and there are still some of those out there. I mean, if we're going to assemble larger vehicles in space to take them on to Mars and things like that, then this facility obviously would be advantageous for those types of tasks as well. So while the facility was designed specifically for Station, we also kept things like that in mind so that we would be able to anticipate those out-year needs and make sure that we hadn't underdesigned.

You can always say, well, we should have made it bigger, deeper, something, but I think it was a pretty good compromise in terms of the cost versus what we thought the ultimate needs and uses would be. So I think we came up with a pretty good design, and it's worked extremely well. The fact that we've been able to run four crew members in there for six hours a day, five days a week, is incredible, and I don't know how we would have got the crews trained adequately otherwise.

ROSS-NAZZAL: Did you give any examples of how the WETF [Weightless Environment Test Facility] was inefficient or outdated?

ROSS: Yes. We would try to demonstrate, first of all, that the hardware just wouldn't fit, and that you would have to totally part-task everything. If the S-Zero Truss is forty-three feet long,

and you had to work on all six surfaces of it, and inside it, you may have to have twenty different workstations that are representative of what you might do on one spacewalk. So you had a little piece here, a little piece there, a little piece there, a little piece there, but there's no way to tie together the whole integrated timeline of how you go from place to place and what tools you need at each place and all that.

So we tried to build a story in terms of how long it would take to train the crews, how many crews you have to train, and how that wouldn't ever come close to working; the fact that you can't do anything in an end-to-end fashion; what that means in terms of the probability of success; what it means in the number of flights you're going to have to fly, because if you can't pack the EVAs as tightly as we had been, because you have less training, less likelihood that you're going to be as effective or efficient, and leave more margin for the unknowns, for the things you couldn't train for, then you're going to have to fly more flights, and that costs a lot of money to fly a lot of flights. So that was a strong economic argument there.

I think those are basically the strongest arguments we made. We certainly looked at the loading, the fact that even if you worked twenty-four hours a day, seven days a week, that you couldn't do all the training that you needed to do—period—no mater how smart you tried to be. So all those arguments came into play.

I guess the other one is robotics. You didn't have any capability to do robotics in the WETF of any sort that would have been anywhere close to being able to give the crews the integrated training that you wanted to do.

ROSS-NAZZAL: That's important.

ROSS: You bet. Yes.

ROSS-NAZZAL: I have two other questions for you about EVA. These might be minor, in your opinion. You also worked with the 5000 Series glove.

ROSS: Yes.

ROSS-NAZZAL: Can you tell us a little bit about that?

ROSS: Yes. When Woody Spring and I were training for 61-B for the spacewalks, there were a lot of crews that were experiencing problems with numbness of thumbs or other fingers. We had, at that point, just standard gloves. They had some adjustability in the lengths of the fingers and that was about it. And if you couldn't fit one of those gloves, then they either had to make a custom glove or you just lived with it.

The design of the gloves was such that most people were getting numb thumbs and maybe other fingers, but the problem was, it had too much bladder that was bunching up right in this area of the thumb [gestures], and it was kind of like every time you tried to grip something, that the nerves that go right through this part of the thumb were getting crushed across—it felt like a pencil. If you could put a pencil in there and just continually crush across it for six hours at a time, that's kind of what it felt like. And what it was doing it was irritating the sheaths of the nerve bundles and causing numbness in the fingers. That, plus the fact that we couldn't get good fits on a lot of people's hands, was convincing the program they needed to do something about it.

So I wore the—I think they were called the 3000 Series gloves, on STS 61-B. Then on STS-37, they had modified the gloves, but then they also had gone off and built for me a prototype glove called a 5000 Series glove, and it was much more conformal to the hand. They basically made plaster molds of the hand and then tried to fabricate a glove that would fit it like a glove. They made the joints on the fingers out of convolutes so that they would be more flexible and less fatiguing to bend the finger joints. They had a thing that they called a segmented palm that was a device that kind of tried to keep the palm from ballooning out too much and would keep the concave part of the glove like you'd like to have it.

We had adjustable capability of where you put the palm bar. The palm bar is a metallic bar that goes across the palm, again to try to keep the hand from getting too much of a balloon. Anytime you pressure something, it's going to try to go into a cylinder or a sphere. So when you've got gloves and you want the palm to be flat and contoured to the concave nature of the palm, it doesn't do that very well when you pressurize the glove or the suit. So a palm bar tries to keep the glove closer to the surface of the skin, on the inside of the palm, and it has a strap that you can cinch down to make it as tight as you can stand it and still function inside the glove, to keep that conformal nature. It had the capability to be moved as opposed to some other gloves that were fixed in place. It also had a flat bar as opposed to a circular cross-section bar, which wasn't as good. So there were quite a few modifications done to the glove, and, again, it was specifically done for my hands.

The gloves that we used in the water tank, the developmental gloves, really showed a lot of promise. They really were less fatiguing, more comfortable, didn't cause numbness in the fingertips, a lot of things. The problem was, when we flew the flight gloves, the only time I got a chance to use the flight gloves on the ground was just before we flew, and I wore them on a

vacuum-chamber run here on the ground. I was continuously doing this [gestures] while I was in the vacuum chamber trying to loosen them up, break them in, if you will.

Since they had got to JSC so late, they had to tear them apart after I had run them in the vacuum-chamber run, to do some final inspections and stuff, and in that process, they didn't get the gloves back the way I had run with them in the vacuum chamber. In fact, they had some bladder that had got twisted in the fingers and things, so when I got on orbit and put the gloves on, I, literally, halfway through the pre-breathe, getting ready to go out on the second spacewalk, I almost wanted to break the pre-breathe and put my old gloves back on because my fingers were hurting that much already. I distinctly remember, about halfway through that second spacewalk on STS-37, thinking, "I can't feel those two fingers. They're numb." So for six hours, I had very poor circulation in those two fingers outside. That, plus the fact that the joints weren't right exactly in the same place as they'd been in the training gloves and a lot of other things, I had to come back and tell them that those gloves were not satisfactory for building for other people.

Fortunately, they didn't give up on the technologies, and eventually the Phase 6 gloves, which are now the standard glove, are a direct descendant of the technologies that were developed for those gloves. Again, I used those on STS-88 and STS-110.

It's kind of neat to note that my daughter was involved in the final certification testing and development of those gloves, and it's kind of neat to be able to wear some hardware that your daughter has helped design and manufacture and build for you to go wear in space. She stayed with my mother down at the Kennedy Space Center area during STS-88, and she would stay up and watch each of our spacewalks and was waiting for us to say something about the gloves, and I made her wait all the way to the end of the third spacewalk before I said anything about the gloves being okay.

Initially, we were going to wear those gloves for one spacewalk and then go back to the older-series gloves, the 3000 or 4000 Series gloves, for one of the spacewalks, and then decide which one to use on the third one, but the Phase 6 gloves were so good on the first spacewalk on STS-88, that I opted to use them for all three, and everybody's using them now. They're really pretty good gloves. They're better by far than what we started out with.

ROSS-NAZZAL: That's quite a compliment to your daughter.

ROSS: Yes.

ROSS-NAZZAL: Let's stop here for a second. We need to change the tape.

[Tape change.]

ROSS-NAZZAL: I just had a couple more questions for you about your role with the EVA and then a couple of general questions. We'll get you out of here by eleven.

You also served on the EVA Maintenance Design Team. Can you tell us a little bit about that, or is that just a relatively minor thing?

ROSS: That was a relatively minor thing. If I can, I'll just talk a little bit about the overall EVA effort. I've worked EVA almost continuously since I've been in the Astronaut Office. It was my first job after we got through our preliminary training, and I've never gotten my fingerprints totally out of it, thank goodness.

When we started building the International Space Station, there were three product groups, in Huntington Beach [California] and Marshall [Space Flight Center, Huntsville, Alabama] and at Canoga Park [California], that were charged with building various different aspects of the hardware. That's about the time I came back from STS-74 and took over as EVA and Robotics Branch Chief again. I went to the program office and said, "Hey, we're going to take some EVA teams and go visit these guys."

And the first response from the Boeing [Company] management was, "No, you're not."

And I said, "Excuse me?"

He said, "You've got to have money to go visit them."

I said, "Why? We're just going out to talk to them and work with them. We're not going to give them any direction. We're just going to work together." So finally, after a couple weeks of haranguing on that, they let us go talk to them. We took a series of people, my engineers—I had three engineers working with me on EVA—and took several XA people, the EVA Project Office people, and a couple, three, four EVA training and flight controller-type people.

We went to all three product groups, and the visits were probably some of the best things I ever did, because they were off designing hardware in a vacuum. They had nobody that they were talking to. Basically all they had was this design book and the EVA hand-tool guide and they were off there doing their own thing. We sat out and, I think, put some standards in place and some continuity in place across all three groups that would have never got there otherwise and we would have had a real disaster. It was a painful process, but it was a very beneficial one and I'm glad that we did it.

Then that followed through as the—in many cases, they were not going to provide any hardware for the water tank. They weren't on contract to do it or they were only going to do a

minimal amount of stuff, and the fidelity was not going to be adequate for our ability to be able to evaluate the hardware and things. So we put in place—and I'd done this way before, but we had a criteria. We basically said, "Okay, we have to have six different EVA crew members do runs on the hardware, and we will evaluate it and we will give you a document back that says this was acceptable or this wasn't acceptable and what you have to do to make it acceptable." And that's the way we've been running the EVA world for a long time, and it's worked very, very well. It comes out of my flight test background, frankly. You go out and evaluate something with a certain set of criteria and then you come back and tell them it's okay or it's not and what's broke and how they need to fix it.

We did that and the program elements would bring in hardware. We'd test it. Sometimes it was very early, in preliminary states, and we would give them guidance on where they needed to go. Then each time around, the hardware would get more refined, more detailed, better. Finally, we got to where we're at today, which is really a pretty good set of hardware, and things are working well.

But it's kind of amazing to me that a big program like that didn't have a better way of getting their arms around that aspect of the job, when it was part and parcel and absolutely critical to making the whole thing work. To me, it was common sense that that's what you had to do, but the program literally was not going to make it happen.

Other things that they weren't going to do were things like we've learned the hard way, over the years, that you need to do manned thermal-vacuum tests of certain types of hardware, to make sure that they're going to function under the vacuum and thermal conditions of space. Again, the program was not going to fund or plan on doing any of those kinds of things, and we said, "We think we need to do this," and we finally convinced them that they would fund one to

clear their consciences that they'd taken care of us, and they allowed us to pick some things that we wanted to test. One of them that we picked was a fluid quick-disconnect valve and we put that in there and the thing failed miserably. And I went, "Yes!" [Laughs] But it was absolutely one of the critical things that had to work, and if it didn't work, you were up a creek. And it just was beyond me that we'd learned those lessons the hard way in the past; why can't you guys understand it?

Likewise, the Station Program was going to do all of their fit checks using computers only; just computer models. Again, we went and said, "You can't do that. It's just not going to work."

And they said, "Yes, it is." And they said, "We're just going to use our documents and we're going to just make sure that everything fits electronically."

And I said, "Okay. If I can give you some examples, will you guys think about changing your minds?"

They said, "Yes."

So I went down and I asked my engineers to go off and look at some of the documents that control the interfaces between various different pieces of the Station and see if they could find some disconnects there. They found three or four within about three hours that would have been significant things, where things just would not have made it; they wouldn't have worked.

I went back the same day. I said, "Here they are. This is the first cut, and there's probably plenty of them out there."

So the program went off and said, okay, we'll do what we ultimately called on-orbit constraints tests, which is physical mating of hardware to hardware to make sure the line lengths

are right, make sure that the keying of the connectors is right, make sure that they're the right size, that the pins match up, all those kinds of things.

Again, it's one of those aspects of building something that you would think that they would all agree was the right thing to do. To be proper to them, I think most of them agree that those were logical things to do, but the program was underfunded, it was constrained, and they weren't going to put things in there until somebody could demonstrate that they had to be put in there or convince them that they had to be there. Same thing like the SAFER unit that we talked about earlier. Nobody was going to do that until they just absolutely were convinced that it was the right thing to do.

ROSS-NAZZAL: Speaking of the Station Program, I understand that you fought pretty hard for them to lower the psi [pounds per square inch] to 10.2.

ROSS: Where did you get that one from? [Laughs]

ROSS-NAZZAL: I found it in an article.

ROSS: Okay.

ROSS-NAZZAL: I was wondering if you could talk about that.

ROSS: Yes. Along with the other things I was going to Washington for, with this trying to sell the Neutral Buoyancy Laboratory funding and things like that, there were several different panels

that were being put together early on in the Station Program to try to scope various aspects of what the design criteria should be. I, on several occasions, would get thrown out of meetings because I was advocating that from an operational perspective we ought to have the pressure inside at 10.2 psi, which would mean after a very minimal amount of pre-breathing of oxygen, crew members could go outside on spacewalks using our 4.3-psi pressure suits. And that's what we did, and still do, on the Shuttle a lot. We'll bring the pressure down. The Shuttle guys didn't want to do that at first. They wanted to stay at 14.7 and do a four-hour pre-breathe in the suit before you went out, and that makes for a really long day. Then we started doing a 10.2-psi cabin and it worked fine.

But I kept bumping heads with the medical community. The medical community says we've got to be able to compare the data that we get on the Station with the data that we generate here on the ground, and we're at 14.7 here on the ground at sea level. I would keep asking them, "You mean the data that you generate in Denver [Colorado] is not valid?" And they'd ignore me. Then I would also say, "We ought to think about what kind of a database we want to generate on Station, because if we're going to go back to the Moon and then, hopefully, on to Mars and other places in the future, we probably don't want to build a facility at 14.7 psi, especially if you're going to want to do daily walks outside on the Moon or Mars. You probably want to build your database at 10.2 or some other reduced pressure."

But I lost miserably. I mean, I could never argue against it or I could never get people convinced that it was the right thing to do. And I wasn't the only one. I mean, there was a lot of people in the EVA community that were arguing for it, but we didn't get the right people's attention or we didn't have convincing enough arguments or the engineering community overrode us as well as the life sciences people.

The other thing that, in retrospect, probably was a little bit of a driver, was now that we've added the Russian components to the International Space Station, many of their things are designed to operate at 14.7 and may have even more problems dealing with 10.2 than our hardware could have or would have.

So that's where we're at, and it does severely complicate doing spacewalks out of the International Space Station. We've got to go through a long pre-breathe protocol. It is subject to the crew messing it up in one way or another and having to start over. It's, frankly, kind of a painful process, not physically painful, but just kind of boring, some of the things you've got to do, and the hoops you've got to jump through. But it's what we've got, so that's what we do.

ROSS-NAZZAL: Let me ask you just a couple of general questions before we close today. What do you think has been your most challenging milestone while working for NASA?

ROSS: Wow. I think the most challenging milestone was getting here in the first place. I mean, literally, we have thousands of people who apply to become astronauts and it's tens that get selected, that are fortunate to get selected.

After getting here, I think it's probably just being able to keep up the same pace for twenty-five years. Physically and mentally, it's a very challenging business, and to stay up and stay competitive for flight assignments and to do the right job, get the job done right so that people are going to be safe and the hardware will work, I think that's probably one of the hardest parts.

When I was doing the EVA and Robotics Branch Chief job there, after STS-74, and when we were right in the thick of the Station developmental work, I was literally putting in seventy,

eighty hours a week, easily, every week. I would take home paperwork on my laptop computer and do e-mail and paperwork at night, and in at six and leave at six or later, and work on weekends, but that's what it took to get the job done right. I mean, literally, you just had to put that much effort into it. That's also when we were doing the ORI [Operational Readiness Inspection] on the NBL and other duties I was assigned. But I wouldn't trade it for anything. I mean, I love every aspect of what we were doing, and I felt that it was important and I think it was important that we get the job done right.

ROSS-NAZZAL: By contrast, what do you think has been your most significant accomplishment?

ROSS: That's for other people to judge, I think. I think one of the things I've tried to concentrate on is trying to talk to a lot of schoolkids. A good share of my PR, the vast majority of my PR, probably, has been talking to kids and trying to get kids to understand that they live once and they get to go through life once and they ought to not waste the blessings that God gave them and the skills and talents that they've got. And I really encourage kids to try to understand what those talents and skills are and decide how they're going to use them through their life and to set some goals and study hard and to work hard to achieve those goals. And if they want to be an astronaut, that's great. If they want to be a doctor, that's great. If they want to be a teacher, that's super. Whatever they want to do, set those goals for themselves. They ought to be realistic and in tune with their talents and likes and dislikes and then go for it, because this country needs smart, productive people to maintain the type of living that we've got for ourselves and to keep our country secure and safe.

ROSS-NAZZAL: That's an important message.

ROSS: Yes.

ROSS-NAZZAL: Would you mind if I asked Rebecca and Sandra if they have any questions for you?

ROSS: No.

WRIGHT: I have one. What type of advice or suggestions do you give the rookie EVAers?

ROSS: To rookie EVAers. Every rookie EVA guy that I see down at the Cape or wherever, before they go fly, I tell them to take some time to enjoy the view. You literally can be so engrossed in what you're doing, that if you're not careful, you can complete the entire EVA successfully and get back in the airlock and close the hatch and never really have a chance to look around and enjoy what you're doing or where you're at. So I tell them to just take a snapshot, take a mental, visual snapshot every once in a while of what they're seeing and what they're doing, and just kind of engrain that as deeply as they can in their brain. It's kind of like a family vacation. If you're the person that's driving and you don't get a chance to look around a whole lot, you get back in the driveway and you go, "Gee, we put a lot of miles on. What did we see?"

From a personal side, that's what I really encourage them to do, just enjoy the moment a little bit. Beyond that, just follow the procedures, do things by the numbers, and just take your time, get it right.

WRIGHT: Since you've mentioned you talked to children so much, how is it that you're able to share with them the emotions of what you experience of being outside in space?

ROSS: I tell them to look at my face. I tell them to look at the smile I've got, and I will also try to kind of paint a mental picture for them as best I can, but after I've done that, then I tell them, "Okay, use your imagination, make it the best you can possibly imagine it is, and I'll tell you, it's better than your imagination can ever make it," and that's basically the way it is. Being outside and being able to do all those things outside with your hands and your brain, is just incredible. Just incredible. To know where you're at and what you're doing is beyond words.

ROSS-NAZZAL: Is there anything you think we've overlooked, that we haven't talked about, about EVA or any of your flights?

ROSS: No, I think that's pretty much it. We went through the last flights fairly quickly, but they were just businesslike flights. We just did them and they're pretty well documented, so I don't think we're missing much.

ROSS-NAZZAL: All right. Thank you again for coming in. We've really enjoyed these three sessions.

ROSS: My pleasure.

[End of interview]