

**GEORGE W. SANDARS**

**June 12, 1998**

Interviewers: Rebecca Wright, Mark Davison, Carol Butler

*Wright:* It's June 12, 1998. We are speaking with George Sandars as part of the Shuttle-Mir Oral History Project. Rebecca Wright with Carol Butler and Mark Davison.

George, we'd like you to start by telling us what your roles and responsibilities were with the Shuttle-Mir Project.

*Sandars:* As you know, or maybe you don't know, that in the early Soyuz-Apollo test program that they had, they set up various working groups to work with the Russians in the various technical areas so that people could go get their technical work done in the ops, engineering, mechanisms, and the rest. So when we started the Shuttle-Mir Program, we followed under that same role model to set up with the Russians and go work in various areas and set up working groups to work with them.

Our particular group is called Working Group 3, and it's a combination of the operations, MOD, and the engineering, if you want to think about it, or integration, payload integration world, or systems integration. We do the engineering functions: the loads, stresses, thermals, flight control, water transfer, ECLSS, all the various technical areas. We interface with the Russians and have those discussions and define the technical requirements environments required for both people to certify to, to end up and say that we can go fly these particular missions.

It was unique people this was the first time that I know of that the ops and the integration people have formed a team together and ended up and worked together so that the operations side of the house and the engineering side of the house can cooperate and end up and come up with an agreeable solution to real-time flight operations for the mission.

So that's kind of the roles that we had. We worked with the operations, both on the Russian side and the engineering side, and to go establish the engineering requirements and the operation requirements in order to fly these particular missions with the Russians.

*Wright:* Were you with the program from the very beginning?

*Sandars:* I was with the program from the very beginning. Actually, there are co-chairmen in Working Group 3. The first co-chairmen were Larry Bell and Gary Cohen out of MOD. Both of those people have now retired. I don't know what Gary's doing, but Larry's working over for Boeing in Space Station. He was the original co-chairman. When he retired and Gary Cohen retired, then Bob Castle became the MOD co-chairman and I became the integration co-chairman.

Before that, I was in Larry Bell's organization and I did the structures work, interface with the structures people over in Russia and my counterpart, who is Viacheslav Mejein, in our technical groups. When I became co-chairman, then we transferred that responsibility structures over to our engineering directorate, James Dagen and a person named Nancy Tengler, who retired from NASA and works for Martin Marietta up in Denver. But that's the way the original structure was set up.

*Wright:* When we were doing the original structure, the team had been, of course, a core team. Has it evolved since then, adding more and more, or have you seen people stay with it from the very beginning?

*Sandars:* A lot of the people have stayed with it from the very beginning. You remember--and you guys, in your interviews, program know this already--that the original plan was to fly one mission, and so we put together a core team of the technical groups that I talked about: electrical, thermal, structures, flight control. We put together the original team, of which normally was one person representing each one of those technical disciplines. And the idea was, we'll go do the minimum that's required to be able to fly one mission, to fly this one mission.

In the middle of that negotiation, while we were trying to get straightened out about the exact working relationship with the Russians in this, was when it was decided to go add the other missions to the flight. So now it became even more imperative that we formalize those particular structures.

On the Russian side, it was a little bit more of a struggle, I think, because Vladimir Soloviev, who is one of the flight directors, a deputy to Valeriy Ryumin, was the single interface both for Gary Coen and Larry Bell. It became apparent to him very quickly that he needed to have interfaces to the integration side and to the ops side. So it evolved then to Victor Blagov was the interface to the MOD side, or the ops side, and a gentleman named Yuri Antoshechkin was the interface to the integrations side, although both of those people were in the ops side of the Mir Program from the Russian side, where ours are ops and engineering or integration.

*Wright:* You learned about how the Russians did their business and watched how their changes started to evolve. Then, of course, you also witnessed how things were done differently here than you've ever seen. Would you talk about one and then the other? Maybe about NASA. You mentioned putting the engineering and the MOD working together. Share some of those experiences of how that all came about and the successes of it.

*Sandars:* If you think about it, one of the things that's always happened before is, engineering has always led MOD in any of the programs that we've had. Engineering people are responsible for going off in the

design, in the building of a particular vehicle, making sure it's certified and delivered. Then MOD takes off and operates the particular vehicle. It was true in Apollo, it's been true in Gemini, it's been true in Skylab, and it was true in the Shuttle Program.

So the engineering directorate had the subsystem managers that went off and certified the vehicle, wrote to the original specifications for the program that were set down, certified it, and delivered it to MOD. Then MOD went off to operate it within the confines of how the vehicle was certified. So they've worked together from the standpoint of saying, "Can I expand my certification or I expand the way I operate the vehicle?" but they've never operated necessarily hand in hand real time, where we end up and we talk about engineering-wise we don't want to go--I'll give you an example. One of our original ground rules, we said, "All right. We don't want to take anything across the interface." Original ground rules with Mir was, "We're not going to transfer any hardware. We're not going to take any Shuttle equipment over into Mir, and Mir's not going to bring any equipment over into the Shuttle."

The reason we said that is because whenever you do this, you have all of the certification that goes with it, the safety documents that go with it that need to be put together. To make it very simple, and it was only going to be one mission, to make that very simple, we said, "The only thing we're going to interchange is air, and we can handle that." And crew. The crew, of course, can go across. So that made it simple from the operations standpoint.

Then the engineering people said, "All right. If I'm going to dock these two vehicles together, I want to be able to fly this corridor up to the point to being able to dock them, to dock the two vehicles together." The ops guys said, "Well, look. That's too constraining for me. Can you open up the envelope a little bit? Can you give a little more leeway to the pilot, this corridor that's there?" So in real time, the engineering people and the ops people worked together to end up and to bring this together.

Now, one of the interesting things, I think, that happened is that even though we were struggling a little bit on our side because we'd never worked together--and it worked really well. And we've made one of the recommendations to Frank Culbertson and the program that any other programs like this, the ops people and the integration people, engineering people, ought to work hand in hand in working these things out. They've accepted that as a lessons learned.

On the Russian side, we discovered, unbeknownst to us, their structure was very--we inferred; I don't know this for a fact--we inferred that their structure is very similar to the structure that we have in the Shuttle Program, in that they have a group that deals with payloads or payload specialists or people who want to go fly on the Mir, and when somebody wants to go buy time to fly on the Mir, you talk to this group of people here. There's a set of rules and criteria that they have and a way that they do business much akin to the way the Shuttle Program, with Richard Swalin, in a payload integration, which have

payload integration managers and the rest of the kind of stuff that deal with payloads that want to go fly on the Shuttle, and a set of documents that the payloads are required to go fill out and criteria that they're required to go stay with.

When we went to sit down to talk to the Russians, we came into the operations side. We bypassed that payload group that was there and went directly to the engineering people and talked to the engineering people and made agreements with the engineering people in the technical areas of electrical, of magnetic interference, and RF environments and criteria about how we could--like can we have the high-gain antenna on when we approach the Mir or do we have to turn it off or put a mask on it. Our radio transmissions--can we transmit when we're in the proximity of the Mir? And all those particular things. What equipment can we have turned on or what equipment do we have to have turned off that would interfere with their equipment that was on the Mir? So all these agreements need to be put in place. We were dealing with the engineering people as opposed to the payload people who had their own criteria that was here.

Then when the program expanded in the number of flights that you end up and see, and we started to transfer hardware across the interface, one of the first things we hit was the IMAX camera that they wanted to take across into the Mir and go film with the IMAX camera in the Mir. We got the technical agreement from the technical people. And when the payload people found out about it, we didn't fill out any of their documentations, it caused perturbations on their side.

The Working Group 6, I think it is, which is the science group which Mr. Nygren was chairman of for a while, entered in through the payload side of the house when they were taking their various science experiments up. He kept having these problems about documentation that he had to fill out and tests that he had to run and verification. He kept coming down and asking us, he said, "You guys have to do this," and we said, "No. We just go talk to our counterpart and get agreement that this is the right way to go do things." And that's the way we discovered that, if you think about it, there were two doors that you could go into the Mir Program. We came in through the back door rather than the front door.

*Wright:* How about the right door? [Laughter]

*Sanders:* And so we've sat back and thought about that, and we've talked to our counterparts about it, and for our particular agreements we had and the things that we needed to get agreements for and the things that we needed to do, that was the right thing to do. Just like our bureaucracy that we have, their bureaucracy on the equipment side of the house would have bogged us down tremendously to be able to go do this. Rick Nygren and his guys finally got passed that and finally got to the point that they were operating very smoothly and very efficiently, as well as the safety people who struggled early in how you

go do safety agreements and the rest of the kind of stuff. They finally got passed that and it became very efficient.

As you saw in the meeting a couple of weeks ago, right before we flew STS-91, the Russians came in with various and sundry pieces of equipment that they carried over with them and asked that it be flown, and that would have never happened early in the program. The bureaucracy would have never allowed that to happen. But the understanding and the trust and the efficiencies that have been built in, or had been acquired through just meeting together and the understandings that allowed those particular items to be flown without much consternation or problems. I think you see some of that that was there. You can kind of imagine how the programs changed a little bit.

We had telecoms weekly with the Russians. Actually, the ops guys had a telecom on Tuesday and we had an integration telecom on Thursday. That became very efficient, to the point that this last mission we didn't have to have a face-to-face meeting with all the technical people and sit down and put out all the information that was unique to this book and sign the books. We could talk on the telephone and just fax the information back and forth and sign the certification documents to be able to go fly.

So it's come a long way in that, and I suspect that that station is going to reap the benefits, because the people at NPO Energia that interfaced with us during the Mir program are the same people that are going to interface with the station guys, or are interfacing with the station guys. So that bonding that's happened over these particular years since 1992 is going to be beneficial to the station.

*Wright:* The bonding that you mentioned that comes from a build-up of trust and understanding between all the parties, was it due to time or were there specific situations or incidents that brought the Americans and the Russians closer together in your area?

*Sandars:* I'm not an expert on Russian culture. Certainly their culture is different than ours, and they're a little bit harder to get to know than we normally are when you meet somebody in the United States. I think time is the big element, but also the respect for the technical work that's being done, the technical respect that you get in the various areas.

I said a little bit earlier, one of the Russian gentlemen, Viacheslav Mejein, last summer when I was over, he had invited me several times and I hadn't been able to go do it, he has a dacha, which is kind of like a summer home or a home that's outside of town, he invited me out to his dacha with one of the other people when we were over there. He and his wife fixed dinner for us that evening. He had his mother there. His granddaughter was there. He showed us around his house and welcomed us into his house, much which we did earlier over here in the United States than they did. So I think it was time built that

bonding and friendship that was there, and trust.

There's a certain amount of trust. You can tell one of the people, "My manager told me that this is what I've got to go do, and I don't have any choice," and they accept that because they've been brought up in that particular mind-set. I don't necessarily agree with it, but on some decisions that were there. They accept that and we go work to end up and find a solution to the particular problem. Whereas they end up and they tell us that they've got a problem with their management, something's happening, we work to end up and help them solve that particular problem. So it's kind of like working with an extension of the people here in the United States, the way we've grown over the past six years. It's been neat. It's been neat.

*Wright:* Once you got to know them, did you find lots of similarities on how they do business and how we do business?

*Sandars:* I find that it's uncanny. Some of their methodologies are a little bit different--technical methodologies--but the end result is the same. I find that their structure, although we haven't seen it as much lately as we did earlier, they were very compartmentized, whereas in Frank's meeting that they had, the Team Zero meeting we had right before STS-91, you saw a lot of the technical people that were there, as well as the medical people, and they're talking about various aspects of the program. If you remember, I talked about the problem with the external tank that we had pre-launch, that we had to go work. They talked about some of the medical experiments they were doing, some of the safety documents that weren't ready, some of the crew training issues that they ended up and had, and this kind of stuff.

Early in the program, the Russians were very compartmentized. The structures guys didn't know anything about crew training, didn't know anything about thermal issues that were there, didn't know anything about flight control issues, and all they did was, they were given a job, they did their job, they sent the information up. It kind of goes up to the top somewhere, goes across, and comes back down. So there was very little conversation.

One of the things our working group did because when we'd have a meeting they were very limited on space, so we would have all these people maybe in one room, and you'd have several little pockets of meetings going on around, but there was a cross-training that was going on. Then whenever you had an issue with the ops guys, we would call all the technical guys in that were associated with that critical issue, and it gave the Russians an appreciation for what was going on as well as an input to the solution.

So at the end of the program, we saw a little bit more of those compartmentized walls being dropped out. I think maybe it's my opinion, my guess, that part of these compartmentized units were because of the security classifications that they ended up and had in their program, but being that the

Shuttle Program and the Mir Program was not classified and we were not dealing with any classified material at all, we saw some of those walls start to disappear and some more information flow back and forth between the two. It was enlightening, I guess is the way I would put it.

*Wright:* Were the meetings the same here as they were in Russia? Did the environments have an impact on how well the meetings were successful, or it didn't matter where you were, things got accomplished?

*Sanders:* It really didn't seem to matter where you were. Of course, we were used to having big meetings, and maybe the Russians were in some of their particular areas. The group that I talked about before may have been accustomed to having payloads come in or a relatively large group of people who were buying time to fly on the Mir or equipment with Energia. The ops integration people weren't necessarily accustomed to doing that, and they struggled with, when we were in the TsUP, trying to--their Flight Control Center there, when we were there, they struggled with trying to find enough office space for us to end up and have our meeting. They finally ended up and found a room in one of their alternate control rooms in the back, what I would call their back room, back of the viewing room, control room. We finally ended up meeting in there most of the time and it worked out okay.

Where we were used to having meetings and we have meeting rooms set up and we did most of ours at the conference facility over here, most of our working group meetings were there, and they seemed to work real well. Whether we were in Russia, other than the logistics portion of trying to be able to find meeting rooms in Russia, and we even have some logistic problems here in the United States at some particular point in time, but the meetings seemed to accomplish all we wanted to go do, and it was interesting, because we both, from our side, we would end up and we would have the individual meetings, and the individual technical people would go to their particular areas to have their meetings, and then we would have a team meeting at the end. Early, it was separate. We'd have a NASA team meeting, talked to all the guys, what transpired in your particular--what are you doing, this is what you need to do, these are the goals we want to accomplish.

And then after a while we started having group team meetings with the Russians and the Americans there. That seemed to work even better, because there was an openness about these, and it would make the technical guys, if they had a disagreement, it would make them stand up and say, "We have a disagreement," both from the Russian side and the American side. We'd say, "Go work on it. Go figure out how to solve that particular one." And it would make them come to an agreement a lot of times about not forcing the wrong technical issue, but they knew they were going to have to stand up and talk about it, and they were reluctant to say, "We have a disagreement," so they would come to some technical solution

and say, "We've come to an agreement and here's what we're going to go do."

So I think the meetings were very effective and it became very quick, at least in my mind. We struggled some early just over the logistics--the language, the customs. I told my counterpart one time, we were having an argument about something, and I said, "Well, that's the difference between Eastern thought and Western thought." And he got upset with me when I said that. One of the meetings subsequent to that, he came back and he said, "Well, you might be right. That's a different viewpoint that we think about things." But very quickly we came to a point--I say very quickly. After a couple of missions we came to the point that it became very routine and very comfortable and there weren't any large debates other than technical debates about how we're going to solve one. There weren't any political issues; there weren't any "This is my turf, not your turf." Everybody worked for a mutual solution to a particular problem.

One of the instances I can try to talk to you a little bit about was when we decided that we were going to use a trajectory control sensor, the TCS, which is a ranger that looks and tells you how close you are to the Mir as you come approaching the Mir, tells you what the range is. It needs a reflector to look at, kind of like a reflector on a bike that you have. So they had the reflectors set around the docking ring and this worked fine until you got within about thirty feet, and at about thirty feet, the sensor lost contact with the reflector, because they were around the docking ring.

In that thirty feet, you could get to a velocity that was outside the range that we had designed the hardware or that we'd said was acceptable to dock with. So we were over in Russia for this particular meeting, and one of the Russian systems people that deals with just all the systems is named Anatoli Patsiora. Anatoli doesn't speak any English. So we had done this analysis and we were getting ready to fly the docking module that the Russians were building. They had put these reflectors around the docking ring, and we were going to need to move them. I was dreading having a conversation with him, because the hardware was already built.

So we had a side meeting, and one of the guys that was in the meeting, one of the MOD guys that was in the meeting with us, and Anatoli and I sat down. I was telling Anatoli, through a translator, what the technical problem was. About half way through the conversation, he realized, he immediately grasped the problem that we were having, and he said, "I understand." I said, "We need an alternate location for these reflectors." He said, "I understand." And the MOD guy started to go explain to him why it was, and he waved at him like, "Nyet," because he totally understood what the problem was, and he went off to work that problem. That was about early afternoon, one evening.

The next day by noon he came back with the solution, with an alternate location to go put the reflectors. It's kind of an example of how willing they were to go work a problem because it was our problem; it was not, "So that's your problem, United States. I don't have to worry about that. You guys go



figure it out." It was like, "This is a joint problem and I'm part of the solution to it." And that was typical of what they did.

*Wright:* A true partnership.

*Sandars:* True partnership. That's exactly right.

*Wright:* Was this your first time to travel to Russia, when you started on this team?

*Sandars:* 1992. August of 1992 was my first travel to Russia. I had never experienced it, although I did work on ASTP. I did a lot of the structures work on the docking module, and at that time I was a structure subsystem manager in Apollo. I did a lot of the structures work on helping build the docking module itself for ASTP. I had never traveled to Russia. So, 1992 was my first trip to Russia.

*Wright:* Would you like to tell us about that, your experiences, both culturally and professionally?

*Sandars:* Well, it's tough to explain, I guess. I had been to Japan and I have been to England. Of course, going to England is not much different than going to one of the East Coast places in the United States, except for the climate, maybe, and a little bit different in the accent. Japan was a little bit of a culture shock. The first time I went, I lost ten pounds over there because I couldn't find any place to eat. I equate Russia to that because it was tough for me to find, being a little bit of a picky eater, to find food that was acceptable, I guess is the right way to put it. It was nourishing, I'm sure it was.

I'll tell you this. You might want to cut this one out. We were at Energia, and they were going to feed us lunch. They ended up and had, as part of the course, they had some cold-cut meat that was there, and it turned out to be beef tongue. I assume it's beef tongue. As a kid, we used to have tongue and I would eat tongue and it was no particular problem, but this tongue still had the taste buds on it. All right? And one of the guys said, "I don't eat anything that can lick me back." [Laughter] So you go look at the food that's there, and it's different, so you struggle with, "Do I eat this stuff?"

Another one of the instances was that they had this bowl, it had soup in it, but it wasn't a bowl normally like we end up and would serve it, that was totally open at the top. It was closed. It had a small hole at the top just about large enough to get the spoon through. So you had to dig down in there and come back out with whatever it was that was in there. So it made it a little difficult to eat some of the stuff that was there.

Later on we became more accustomed. We became more accustomed to us and about things that we ended up and liked--fish and some of their meat that they chicken-fried kind of like we chicken-fry it.

It's not the same. Some of their soups, some of their salads that they have were very good. They have some beautiful rolls over there. They look like hot rolls except they're cold, and they're really pretty. They really look good, but they're stuffed with cold cabbage in the inside of them, and it's kind of sweet. You bite into this thing, expecting to have a yeast roll, you know, and you end up with this cabbage on the inside. So I'm not necessarily a connoisseur of their particular food.

My first impression was of Moscow, the first time I went--of course, it was in August and it was not cold, it actually was pretty warm; it was humid and it was warm the first couple of days that we were there--was how dingy and how unkept and how run down a lot of the buildings and the streets and the area was. It was kind of depressing. The hotel was very nice. We always--"we"--I had always stayed at the Penta, and the hotel was really nice, but the area around it, the shops were not painted on the outside. You couldn't see in any of the windows. There weren't any bright signs. There weren't any neon signs or any of the other stuff. So it was kind of depressing. You would drive down the street and you'd see a building that was halfway under construction, but the weeds had all grown up and the crane that was sitting there was rusting. So the facilities around there were pretty bad.

One of the things that struck me is that there are very few public rest rooms. None of the stores have any rest rooms for customers to use. The first time we were over there, the only ones that had any rest rooms were McDonald's and museums and libraries. If you could find a museum or a library, they had a public rest room, or the hotel. But other than that, there weren't any rest rooms. And even in the museums and libraries, there is no toilet paper, so you had to carry your own toilet paper. I told somebody I didn't like to travel to any country that I had to carry my own toilet paper.

So it was a culture shock for me, it really was. But after several trips, you learn to get around on the subway. Of course, when I was in London, of course, the subways are very well marked and easy to get around on. In Tokyo, the subways are very easily marked and easy to get around on. Even though they're Japanese names, they have the English characters for the Japanese names. When you get outside Tokyo, it becomes the Japanese characters that are there and you have a tougher time. But inside Tokyo, it's easy. In Moscow, they're all in Russian, in the Cyrillic Russian. So it takes a while to be able to get yourself around on the subways, but after a while you learn to get around on the subways.

The flea markets were interesting to go shopping. The Arbot, which is a street that runs down toward the Kremlin and out, the first time we went was covered with card tables, with people selling various and sundry things, anything from a spacesuit to Russian uniforms, medals, to shotkas, the fur hats, and the stacking dolls and the rest of the kind of stuff. You could buy almost anything. And you could bargain with them, and even though the dollar was supposedly illegal, they preferred dollars and you could negotiate in dollars.

So that Arbot changed and it moved out to--I can't even remember the name of it now, but it was an area kind of outside of the subway ring--Ismylva. You could go out there and there were nothing but shops, and bargain with the people. There was a lot of things for sale. One of the things, I guess, was sad. You would see elderly people, as you walked into Ismylva, having household goods that they were selling. Although they didn't say it, you wondered if because of the inflation, if they were ending up having a hard time.

There was an article that I read in the *Moscow Times* and it talked about this lady that was trying to buy a pound of butter, and she went to one store and they wanted several hundred rubles for it. She thought that was too high, so she was shopping around to find it. She couldn't find it anywhere else. She came back to buy it, and it had gone up by 50 percent in the time that she was gone. That's how inflation was impacting the older people in Russia. You wondered how the older people were really getting along.

The other people were doing great. I mean, they were sitting up a little kiosk on the side of the street and selling everything from bananas to blue jeans, to whatever. They were doing great. But the older people that were on fixed pensions were having a hard time with inflation. And I hope they made it, I really do, because even though we were raised up in a time difficult with the Russians, the Russian people are neat people, they really are.

*Wright:* You worked with them for so long. You mentioned that they were here and even visiting homes and things. What were some of their perceptions of America? Did they share a lot with you about how different it was here?

*Sanders:* They were amazed about our stores and the variety of choices that you had. One of the things they would do, at least some of them would talk about, when they did have money, because inflation was so high, you didn't want to have money; you wanted to buy goods. You would trade goods. So they would go into a grocery store, and let's say there were beans that were on the shelf. Well, they would go buy as many beans as they could. They'd go take them home and then they'd trade it for something else. But whenever they went into one of the stores, they didn't get a lot of options.

We saw later on, the last time we were there, in some of the supermarkets that they had, they opened up one of the--you know, the Penta, there is two Olympic stadiums that were built for the Olympics that were there. Underneath one of the stadiums they opened up a grocery store. Actually, it's kind of a little shopping mall down there, and electronics and the rest of the stuff. They opened up a grocery store. The last few times I was over there, you could go into that grocery store and they had a lot of variety of things that were there that were brought in, a lot of things from Switzerland, from Germany, the rest of the

kind of stuff like this. Some of the stuff from Russia. But you could get Cokes and Pepsis and this kind of stuff like this, Oreo cookies, this kind of stuff like that.

But when we were first over there, the store shelves were fairly barren, and it wasn't unusual to go to a grocery store and they not have anything on the shelf. So they were amazed about the variety of our supermarkets. It's an interesting thing that they would go do. They would come over here and if they were going to be here, for instance, two weeks, they would go shopping and wouldn't buy anything, but they would go shopping. They'd go to Baybrook Mall and they'd go to all the stores in Baybrook Mall, and they would go to Venture over here, and some of the other particular stores. Then a day or two before they were ready to go home, they would have their list and they would know where the cheapest places were, and they would go buy what they wanted to take home.

*Wright:* Learned how to be bargain shoppers.

*Sandars:* Learned how to be bargain shoppers. And they were bargain shoppers. They knew that before they came over. They would always take this stuff home. One of the things that they'd do, when Fiesta was here, they would end up and like to go to Fiesta, and they would end up and buy sausage and cheese and crackers, or they would bring it with them and they would end up eating in their room, save their per diem, and that's what they would end up and use to buy stuff to take back home with them. It's not much different than we would end up and do, but it was interesting.

They never talked very much about--I tried to talk to some of them about ownership, what it is to own some property, and this kind of stuff, and they didn't talk very much about that, about how strict the government was or what their freedoms were and the rest of that kind of stuff. So I never really got into a lot of that conversation with them to a certain extent. But they enjoyed coming over here. They enjoyed coming over here, I think, because the per diem they got was a lot of money to them. They could save it and they could buy a lot of things with it. That's understandable.

Somebody had told me once, and I didn't see it written down, so I don't know that it's true, and I never really pried into any of them, they said an engineer in Russia, when we went over there in 1992, yearly salary was \$600.

*Wright:* Wow.

*Sandars:* And so you can see for a minute, if they came over here to the United States and they were getting \$35 a day per diem and their hotel paid for, two weeks' worth of per diem was a significant amount of money to them.

*Wright:* A bonus, wasn't it.

*Sandars:* It was. It was a bonus. I don't know how it is today. They still like to come over here and they still like to get the per diem, you know, but it's not as prevalent as it was when they first started.

*Wright:* I'm going to shift you back a little bit to the program itself and your responsibilities. When we first began, you mentioned the different areas that fell under your responsibility--electrical, flight control, thermal, and so forth. Was there one that was a more difficult component to get up and running under this program more than the others, or more challenging maybe is a better word?

*Sandars:* No, I think all of them had their technical challenges. In the world of structures, you had the technical. They had to work hand in hand with the flight control people, because you had the technique of, as you approached the Mir, you had to worry about firing the Shuttle thrusters and about what kind of loads that the Shuttle thrusters imposed on the Mir and was the Mir structurally adequate to end up and accept those loads.

*Sandars:* You had to worry about the docking conditions and being able to fly the Shuttle to a point to give you a set of docking conditions that allowed you to capture and then to structurally attach together so that you could end up and fly together.

Early in the program, there was a technique of the ops guys, and this is one of the benefits that came out of the program, is that ops guys had a technique of where when the Shuttle would approach the Mir, what they called the velocity vector, and so you had to fire the upward firing thrusters to keep your closing rates from coming together, to slow the Shuttle down so that you could be within the right velocities to dock. They discovered that if they went on what they called the R bar, rather than the V bar, which is the radial direction, just by mechanics, if you just didn't do anything, they would start to separate. So you had to fire the downward firing jets to move the Shuttle in. So we changed from flying on the V bar to flying on the R bar, which was a better technique, and allowed the structures guys to not have to worry about the plumes from the Shuttle RCSs ending up in impacting as much on the Mir.

The flight control guys had to worry about where was the combined CG, what did the Mir really weigh, what were the structural responses for if the Shuttle was in control, as it controls the attitudes, what were the responses, what were the dead bands. So they had to worry about being able to put the right notch filters in so that they wouldn't excite the combined frequencies of the two.

The electromagnetic guys had to worry about what equipment was on, what equipment was off, and what kind of antennas transmitting power that you had to go do so that you wouldn't damage or cause

some problems on either one of the vehicles.

The thermal guys had to worry about the thermal constraints on the Shuttle of the various components getting too cold or too hot, as well as the Mir had to worry about they have to be so that their solar arrays can get full sun, and they had thermal constraints because early in the program they had a lot of problem with their thermal cooling systems that were there. Some of the cooling loops went out. As probably you've talked to some of the people, some of the things that they had to go do to get these external loops working.

There were a lot of issues about the atmosphere in the Mir and the atmosphere in the Shuttle. Could the Shuttle ECLS system take the humidity out? Could we give them extra oxygen, extra nitrogen? When the hatches were open, would it overload our ECLS system? What were the temperatures in the Mir that we had to worry about? And the rest of the kind of stuff.

So, every one of them had their own technical issues or hurdles that we had to go get over with, and the Russians had to get an understanding of how the Shuttle worked, and we had to get an understanding of how the Mir worked. That was part of the problem early on, because we would end up and ask, "How does your system work?" And they weren't accustomed to somebody asking them how their system worked, because they had been working in this classified environment. So when we would sit down and talk about it and say, "Look. We need to understand that because we have to have this data to be able to evaluate our system, and we'll be glad to give you our data on our system," and little by little that worked itself out, and transfer of information came freely across.

We did find that their system seems to lack the documentation depth that we have on ours. There's people that know their system, that understand their system, and they've done the certification and the analysis, but getting the documentation on it was difficult.

*Wright:* Speaking of transferring, can you talk to us about the water transfers and how that all came about?

*Sanders:* It ended up that we talked about early in the program to say that we weren't going to transfer anything right before the cross, and then it became very apparent to the Russians and I guess it became apparent on their side, at least to me it became apparent on their side before we talked about it on our side, that the Shuttle could become a logistics transfer item for them, that could help them in their logistics of their items that were there, particularly the bigger things that they weren't able to bring up and down readily on their Progress.

One of the critical items they had was water. One of the Russians proposed that he would be able

to develop a system that would allow the Shuttle to transfer water over to the Mir, but to do that, he wanted Tommy Holloway--this is when Tommy was program manager for the Mir, Phase One--wanted Tommy to give him--I'll remember what the dollar was, but it was several million dollars, and he would go set this program up.

Tommy came back and said, "No, I'm not willing to do that. I'll have us go figure out how we can transfer water." We said, "That's no problem. We can just take a hose and run it across and just allow the water to come out of one of our tanks, and we'll put it in one of their tanks over on their side."

Wasn't quite that easy. It turns out that we use iodine in our system as a biocide for, as the guys put it, [not] growing bugs in the water. So the Russians use a silver compound as their biocide. Their system is not designed to take iodine. So if we were going to transfer water over to them, we need to figure out how to take the iodine out of our system. So that was the first step.

The second step is that part of their drinking water and part of their medical protocol is to put minerals in the water. So they drink mineralized water and that's what their doctors think is the right thing to go get part of their body supplements and mineral supplements from is out of the water. So they not only wanted water that didn't have iodine in it, but had silver as a biocide, they wanted minerals in the water. They would accept water in two classes. They would accept what they call potable water, or drinking water, and technical water. The technical water didn't have the minerals, but it did need to have the silver biocide.

So we went to Hank Rotter and Hubert Brasseaux and Dick Sauer here on our side that were supporting us in Working Group 3, and asked them to come up with a system by which we could take the iodine out of our system and we could go put the silver and the minerals into the water.

We originally thought it was going to be fairly cheap. It ended up being fairly expensive. I don't remember what the total was now, but we had to go build a bunch of these what we call CWCs, which are really wastewater containers that we had built for the Shuttle, and we had to go build some to make sure that we put them in these bags, then we'd transfer these CWC bags over to the Russians. Each bag would hold just about 100 pounds of water, a little bit less than that, somewhere around 90 to 100 pounds of water, depending on how full it got.

So we started about--I don't remember which flight it was now. It was the second or third flight, about, we started transferring water. The first water that we transferred, we developed this cartridge. This cartridge had a resin bed in it that would take out the iodine and then as it passed through, you would have iodineless water come out the other end, and there was a place to put a syringe and put the silver biocide in, and put the minerals in. The minerals were already measured in syringes that, per CWC, you could end up and put so much for each CWC that was in there.

Well, the first cartridges that we put together, because of the launch environment and the packing that we had, there was a water channel developed, such that the water bypassed the resin bed, and we got iodine out. You put the silver in with it. Well, the silver and the iodine combined into a silver iodide compound, and it was not now a biocide anymore. The Russians used it anyway. With one of their systems that they could have, they could go in and separate it out. But it was not as successful, and we had a little bit of egg on our face the first time around. We went back and did some more work on it. Finally got a system that worked, and we've become very successful.

One of the interesting points about that is just recently the medical people have come back and said that on our side that our astronauts are getting too much iodine and they want the iodine taken out of our water before we drink it. So they've used this system or a similar type system to this. In the interim, till they get a final fix, they use this in the interim to produce non-iodine water for our astronauts as they're on orbit. So that's kind of the way it came about.

We set a contract in place about how much water we were going to deliver. We exceeded that contract with the amount of water that we delivered to the Russians and they were very grateful. It saved them a lot from the standpoint that they didn't have to end up on their Progresses and put water on there. They can put their food and their other particular logistical items, as well as the Shuttle flying up the larger items such as gyroscopes and batteries that they can't necessarily fly on their Progress. That was one of the interesting parts of the program.

*Wright:* That was one of those unexpected benefits for the Russian side.

*Sanders:* It was one of the unexpected benefits. That's exactly right.

Another one that was interesting, too, is the electromagnetic people. I told you about the difference between their customer groups and the engineering groups. Whenever you had some electrical box that you were going to put on the Mir, that you were going to operate, they had a requirement to do what they call EMI testing, electromagnetic interference testing, on the box. The way you go test that is, they have a ground-based system which is an exact replica of the electrical system on the Mir. You go plug it into their system and test it and see how it operates. We don't normally do that.

Our methodology is a little bit different. We have a set of criteria that says you can go test it in our laboratory over here, and if it doesn't exceed a certain level, it's acceptable. So ours is to a criteria to a standard across the United States; theirs is to a specific set of criteria for the Mir. So the science guys were finding it extremely difficult in trying to meet their criteria. Well, one of our guys, particularly a guy named Art Reubens, who is an EMI expert, has since retired, Art worked with our labs over here to design



a system that emulated the Mir, set up a criteria there that we could test the boxes here for EMI and the Russians would accept the results of that particular one. So the testing, rather than having to ship the boxes to Russia to be tested, they can be tested here and accepted by the Russians. So that was another one that was very similar to the water transfer.

*Wright:* The evolutions were internal, external, every which way, and I guess international as well.

*Sanders:* International as well. That's exactly right.

*Wright:* You've worked for NASA since 1962.

*Sanders:* Right.

*Wright:* I'm going to make an assumption that on your first job that you would have never thought you'd be ending up talking with the Russians on so many detailed pieces of information and working to put a successful partnership together.

*Sanders:* You know, STS-91 we went down to the KSC, which you guys were there doing some work there. I took a tour on a Sunday. I had my wife with me and I took a tour, and we went to the Saturn 5 building. If you've gone through the Saturn 5 building, the first part of it, it talks about the Russian space race and the United States space race, and the Russians in space first. So that was all happening in the middle to the late fifties and early part of the sixties. I was growing up in that environment in college at that particular time, looking at the Russians after the Second World War and the relationship that we had with the Russians. If somebody would have said that in thirty years from the time that you came to work for NASA, that you would be working with the Russians in a combined effort, or even talk about the Apollo-Soyuz docking project, working with them, I would have told them they were crazy, based on the strained relationships that we had in that particular time. I thought KSC did an excellent job in the front end of that, showing some of the--I call it hysteria that was built up in the early part of the program that you saw.

I came to work in 1962, came to work in the Structures and Mechanics Division, the Structures Branch, and I stayed in the same branch and in the same division until 1985. At one time I thought that I would end up and retire out of that particular one before I came to the program office. But I never thought that I would be working with the Britains or the English or the Japanese or the Russians or the Germans or the Italians. We've got to work with all of those particular ones in various and sundry forms on various things. It's been an interesting program.

Mir is kind of--what's the right word? A mini Shuttle program, if you want to think about it, because it has its own characteristics. It was a program within itself. I'm sorry to see it end from one aspect, but from the other aspect of getting on with the Space Station, it needs to end and we need to move into the next thing, which is Space Station itself, which I think, as Frank will tell you, we've learned a lot about how to operate by going through Mir.

*Wright:* So much has happened real time, and really when you look back how many years, there weren't that many years for Shuttle-Mir. It's just a lot happened during that time. Has there been a highlight for you that really is significant in your memory during that time period?

*Sanders:* I think two or three things. One of the highlights to me is, I just said a minute ago, I talked about in the late fifties and early sixties, the relationship we saw even in the fifties, we saw with what the Russians and what we thought of the Russians, and what the newspapers brought to us. Now, having worked with them very closely one on one, and the people that were there, and seeing the individual people, they're not much different than us. They are a warm people, a "relationship" people. They like relationships. Takes a little while to build it, but they like relationships. I think that's one of the highlights that I see, is building friendships with them.

The other two things are to see an idea like in Mir where we end up and say, "We're going to fly one flight. We're going to fly up there one time, open the hatch, shake hands, smile, take our picture, undock and come home," a little more than that, but not a whole lot, to a point that it becomes a program that is beneficial both to the Russians and to us.

It's a snapshot of how we will probably have to work with Station. And to see then an idea that says if we want this program to be on a regular basis, is to build this docking module, put it in the Shuttle, a mission that in 1992 had not even been thought about, and then in--when did we fly? What was that, 74? STS-74. To end up and go fly that particular mission with a cargo that in '92 had not even been thought about, to build it, certify it, put it in the Shuttle, fly it, attach it to the Mir, and dock to it on a regular basis for the rest of the mission is a highlight.

Don Noah was our project manager on the docking module and worked very closely with the Russians and a Mr. Efremov over there, to end up and get the thing built and delivered. He did an excellent job of that. There's a lot of our guys that had worked hard to see our team--another highlight for me is to see the ops and integration guys work together hand in hand to arrive at solutions, engineering and operations solutions to go fly these two vehicles together, two vehicles that were already built, built to a set of criteria that were not necessarily to a criteria that we were going to end up and ever go dock together.

To go put in place the operations and engineering requirements to be able to go do that is another highlight for me.

*Wright:* Any lows? Any points during the time that you thought maybe the program wasn't going to make it or something shouldn't have happened that could have caused a problem?

*Sanders:* I don't ever remember a time that I didn't think we were going to make it. There were times that were difficult and frustrating. I remember something that comes back to me every once in a while. It's back 1968, 1969, whenever we landed on the moon. I can't ever remember the exact date. I had been working hard in Apollo, in '62, to go get the Apollo vehicle ready to go fly, and the objective was to go land on the moon. The guys in the office worked on the LEM and the Apollo spacecraft, and I'd been instrumental in working on the structures area of the Apollo spacecraft.

The day we landed on the moon, I was standing in the division foyer for Building 13 over here, and a guy walked by and he says, "I can't believe we did it! We landed on the moon!"

And I said, "Well, isn't that what we were supposed to do? That's what we've been working all these things for." And that's kind of like the Mir Program. We ended up and the guys said, "Let's go fly these missions and put it together," and when we did it, it was kind of like, "Wasn't that what we were supposed to do?"

So I don't think there were any lows. There were difficult times, like anything. There were technical arguments that were personalities that were involved, but yet you worked your way around and through those particular things to end up and go get where you wanted to go. There was never a doubt in my mind that we wouldn't do it.

*Wright:* You said that you're going to be leaving in January for retirement.

*Sanders:* January 2, 1999.

*Wright:* Did you pick that date to give you enough time to finish Shuttle-Mir and all the paperwork associated or that's your time?

*Sanders:* The Mir ended up and crossed my mind. Of course, the Mir was a second job for me. Our primary job in our office is to define the requirements for all the Shuttle elements to fly, as well as all the payload. So we had both the systems integration and the cargo integration side of the house in our particular shop. So that's our primary job.

The Mir, to us, we were kind of matrix to Frank as a secondary job. And so, yes, it crossed my

mind that the end of the Mir Program was within the time that I was still going to be here before I retired, but the to pick the date was not driven by Mir. Thirty-six years is enough time.

*Wright:* So you're ready to move on and watch others put the Station together?

*Sandars:* And watch others go do that. I just hope I get to see the first Station launch before I retire.

*Wright:* We do, too. We thank you for your time. We wish you luck in your next life, but we know that you've got a few months here and I'm sure every day they're going to get all the work out of they can till you're gone.

*Sandars:* That's exactly right. I appreciate you guys taking your time to do this. I think this is something that's well worthwhile.

*Wright:* We thank you again.

[End of interview]