NASA JOHNSON SPACE CENTER ORAL HISTORY PROJECT
ORAL HISTORY 2 TRANSCRIPT

WALTER W. GUY
INTERVIEWED BY REBECCA WRIGHT
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WRIGHT: Today is November 27th, 2006. This oral history is being conducted with Walt Guy in Houston, Texas, for the NASA Johnson Space Center Oral History Project. The interviewer is Rebecca Wright, assisted by Jennifer Ross-Nazzal.

We were just chatting about the requirements and the development process for the equipment needed to be able to do the EVAs [Extravehicular Activities] on going to the Moon. Would you share with us those details and how that process was developed?

GUY: Okay. I think starting back at the point that the initial pressure protection, the isolation from the space vacuum, was the initial concern, so the Mercury spacecraft, the Gemini spacecraft, basically had the problem of providing pressure protection in case the vehicle lost pressure. That was a very similar job to a fighter pilot, and in fact, the early suits were built by the same vendors that built the military suits, and in fact, the NASA spacesuit experts came from the Centers that did the military suits. The Naval Research Lab [Laboratory, Washington, D.C.], I believe, was a big contributor to the people that populated NASA Wright-Pat, the Wright-Patterson Air Force Base [Ohio]; probably some from Brooks [Air Force Base, Texas].

That was really the initial part of the spacesuit activity. As we began to look at bigger challenges of more than just vacuum protection, for example, the beginning to go EVA [Extravehicular Activity], which was done on Gemini and then, of course, done on Apollo, both orbit and on the Moon, the requirements were compounded. For the Gemini EVA, the spacecraft

still provided all the life support. There was some concern for thermal conditions, but the EVA was very short, and those weren't substantial concerns. They could be accommodated pretty easily because of the time frame. But when you began to talk about six-hour EVAs on the lunar surface, there was a substantial increase in the requirements for some thermal protection.

The suit evolution, as I said, stemmed from the military but became more and more customized to the NASA objectives. There was the added backpack, which had the life support system and all the thermal control hardware, which was not a function of anything that was ever used in a military airplane, as far as I know. I don't really know that to be true, but I don't know of any. We didn't use or consider any of those. There were things called ventilators that you sometimes see carried along with a suited crewman that just provide some cooling and ventilation for the Earth conditions, but I don't think there was a spaceworthy variety of that.

The big challenges were you needed oxygen, obviously, and you'd carry that in a bottle. You needed to scrub out the CO_2 and the Navy was using lithium hydroxide in the submarines, so we used lithium hydroxide. The cooling, though, the first idea was we'll just cool the gas down, and we'll blow the gas through the suit. It turns out, though, that the gas has very low cooling capacity. That really wasn't a very good answer.

We had a very smart doctor. Dr. [John] Billingham was with us, and he had done some work with a liquid-cooled garment that you wore next to your skin that pulled off most of the heat, and all you needed the ventilation for was the humidity control. He suggested that, and that was implemented. When we issued the RFP [Request for Proposal] for the lunar suit, the EMU [Extravehicular Mobility Unit], it required the use of liquid cooling. Again, that's a little hazy memory. I don't have direct recollection of the actual Request for Proposal. It's possible that

that was an add-on after the initial procurement. I don't really know whether it was or not, but it was done very, very early.

I'm almost sure it was part of the original procurement, because I remember when the proposals were evaluated, the people that bid the spacesuits were responsible for this cooling garment, and it was brand-new to them. They didn't know anything about it, so as part of the proposal evaluations, there were some really strange implementations of that, and I can recall having part of the evaluation process is to do the engineering to figure out who had a viable concept and who didn't.

Back to the backpack, the only thing that you needed was a pump, which was easy, and a fan, which was easy. The lithium hydroxide was easy. The oxygen tank was easy. But then you had to get rid of the humidity, and you had to cool the gas. We thought about a desiccant, but that was too big a volume, so we coupled the condensing the gas, where if you cool it, the water condenses out. You can use that same cooled gas and then collect the water that you've condensed out. That worked out all right.

But we didn't have any way of cooling, and there was a brand-new concept called a sublimator, which was a device that used an ice layer as exposed to space, and the ice sublimates, and of course, anytime you have phase change going from ice to gas, there's a lot of heat involved in making that conversion. There's a lot of cooling available for that. It's just like the perspiration evaporates on your skin and that cools you; same principle. If you start with ice, you get a few extra BTUs [British Thermal Units], but you get the same cooling effect. We used a sublimator.

That basically was the life support system. When the procurement was put out, there was a suit, and then there was the life support system, and they had to be integrated, and the

government was the integrator. It turned out my job was the Systems Engineering branch chief, it was my job to integrate. We had all the interface control documents and the end-item specifications and the master specification and the master schedule for everything, and we did all the integrated testing.

NASA, even at that point, had, I believe, the only thermal vacuum test capability for humans. There were some other altitude chambers around that could get pretty close to a vacuum, but not all the way. But I think we had the only true vacuum chamber for the human capability and with a capability to test under thermal conditions. All the integrated testing, certification testing, was done out of my branch, and we used the Chamber B was our test chamber. It's a fairly large chamber. It's not nearly as large as A, but plenty big for a human.

We had to construct a lunar crater. It didn't look like a crater, because it was basically just a thermal crater, but it could simulate a crewman in a crater and the focusing effect of the crater heating up the spacesuit backpack. We had to look at it. At that point in time there were no restrictions; we had to look at very hot and very cold cases. Also the restrictions of how big a crater a crewman could traverse was still an unknown, so there were some specifications created. It had mainly to do with the slope of the wall, because the thought was he was going to have-to-walk-down in there. The depth of the crater and the slope of the wall gives you how severe the thermal environment can be, and we did all the testing.

We had a really very comprehensive program. We had one branch which—you mentioned Jim [James W.] McBarron [II], he was in [the area] that developed the suits, and they had their own contractor. It was ILC, International Latex [Corporation]. Then Hamilton Standard had the backpack, and that was another branch. Harley [L.] Stutesman , I believe, had that branch. Then we had the Systems Engineering Branch, and we integrated them together. It

wasn't too long before the government figured out that two procurements was a bad idea, and they integrated the procurements and novated the suit into the backpack. Hamilton Standard turned out to be the prime [contractor].

WRIGHT: When you were talking about the testing, you had human subjects for testing. Were those members of your staff, or did you have volunteers that would work, and did you train them to do specific things in the suit?

GUY: It was a volunteer organization. The test subjects were volunteers. But most of the test subjects had something to do with the division. They were members of the division or members of the contract support staff. That wasn't always true, though. We had some MOD [Mission Operations Directorate] people, some of the SR&QA [Safety, Reliability, and Quality Assurance] people. In fact, I'm not sure which program it was—probably Shuttle—Richard [J.] Bussey, who still works in SR&QA and supports this division, he was a test subject. For the Apollo time frame, it was Jack [Jackie D.] Mays. He was a technician, and he volunteered, and he was basically the certification test subject.

The way they did things in those days is they assigned the astronauts to individual areas, and Ken [Thomas K.] Mattingly [II] was assigned to the suit area. He wanted to be a test subject in one of the runs. He didn't fit the suit at all, but, astronauts had their influence. He was a really good test subject; it's just that he didn't fit the suit very well. But he ran probably the most strenuous one of the tests, if I remember correctly. It was a really really tough test. He's a small, wiry individual, but it was a tough test. But he wanted to experience the use of the suit in the environment, and he did.

WRIGHT: What type of risk did people take? Were there some [risks] in doing these types of tests?

GUY: Certainly there's always some risk, but the chambers had emergency repress capability and the suits and backpacks were designed to be several kilometers away from the vehicle, so [you're] within seconds of getting help, and when you're on the Moon, you [have] no help. The suits were very reliable, and the backpacks were very reliable. They had emergency systems. Within the chambers, we had emergency repress capability, and we had what we called "lock observers," which were a rescue team that were always outside of the chamber and in an airlock. All you had to do was equalize the airlock with the chamber, and the [rescue] crew could immediately go in.

We trained for emergencies, and I don't know of any really life-threatening emergency we ever had. We did pop a helmet, but I don't think we were at vacuum when that happened, when they didn't get the helmet latch on. We did lose one of the hoses popped off one time I can recall, and we did an emergency ER and rescued the crew. I don't recall anybody getting injured ever in any of the testing we were in.

WRIGHT: Once the suits were certified, did they leave your facility and then go on for a life of their own?

GUY: The government really never took complete ownership of the hardware. We always kept the prime contractors involved in the hardware, but we had ability to do tests. We had the ability

to provide hardware to KSC [Kennedy Space Center, Florida], and we did a lot of training here on-site. We had a lot of training suits, and they were provided to the astronauts for training.

As close as we ever came to actually owning the hardware is during Shuttle. Actually, [on] the third floor of Building 7, where the division was located, we created a processing lab for the Shuttle EMUs, and we actually processed them there and shipped them to KSC from there. But again, that was run by a contractor, the prime. When you had a prime contractor, you'd get a field services contract with the prime contractor, and they would continue to take care of the hardware. The government was involved, but it never turned out to be a government activity, a direct government activity.

WRIGHT: During the sixties, of course, the agency was focused on going to the Moon and meeting the goal that President [John F.] Kennedy had set, but that wasn't the only project. You had many others. I believe there was already talk about [Space] Station and different types [of Stations]. One of the ones that we found when we were looking for some information about you is the big Gemini spacecraft system, and that you were somewhat involved in evaluating that as well. Do you have any recollections of what that involved?

GUY: The thought in those days was that the space program would be very fast paced. Turned out that's not true at all, but that was the thought. We began before we got to the Moon, we began looking at the Space Station and some intermediary spacecraft to bridge the gap. There was, I believe, a large Gemini. There was something called the AAP Program, Apollo Applications Program, which was a long-term Apollo vehicle.

In fact, we developed a life support system for that, and I was able to get Spacecraft 6 from Rockwell—it was a structural spacecraft—and bring it in and put it in our twenty-foot chamber. Then we outfitted it with a life support system that had capability to go—I've forgotten—forty-five days, maybe; thirty days. I've forgotten what the length of time for the program was. I think it was forty-five days.

But we developed a CO_2 collection system. I mentioned earlier lithium hydroxide was sort of the standard system, and for short missions that works fine. But it's a chemical, and you use up the chemical, and then you've got all this chemical laying around, plus you have to take it all up with you.

When Skylab started, their life support system was based on Gemini, which was lithium hydroxide, but to carry up enough lithium hydroxide for the long Skylab missions, it was—I don't remember—thousands of pounds, and it took up a lot of space. We had test data—I said forty-five days; it was fifty-six days. The reason I know that is because when we went to Program Manager Bob [Robert F.] Thompson and told him that he had another alternative if he didn't want to carry up a ton of lithium hydroxide, and we already had built the unit and tested it. We could prove that it worked, and he accepted it.

We flew a molecular sieve was what it was called. It's a chemical that absorbs CO_2 and can be desorbed of CO_2; you can use it again. Then we used silica gel to absorb water, and you can desorb it, too; it was a mol [molecular] sieve with a silica gel for water. It was four-bed system in its earliest reincarnation, and we had some other versions where we actually packed some heat exchangers with some pellets and used those. There were a lot of different configurations. We had a fifty-six-day version that could be used and was used for Skylab, that was sort of an outcome of the extended duration.

In fact, that's really where Skylab came from. It was thought to have been an intermediate Station; that you could use the Apollo vehicles as communication, and you could use the large hydrogen and oxygen tanks as the habitability volumes, and ended up using a hydrogen tank. The first thought was you'd first use it full of hydrogen, and when it was empty, you'd outfit it. But that really wasn't terribly practical, so they used a dry tank and launched it. We worked, although the Spacelab itself was a Marshall [Space Flight Center, Huntsville, Alabama] vehicle, we worked a lot on the life support part and the thermal control part. The life support part was not in the Skylab itself. It was in sort of an equipment module; it had a name, but I don't even know what the name was these days. But that's where the Gemini life support system was.

Of course, as I said, the molecular sieve was added later. They basically had the outfitting of the hydrogen tank and the ventilation system, and the rest of that was pretty much us. The issue became the thermal conditions, that since it really did not have a lot of thermal conditioning, the hydrogen tank was made to carry hydrogen. It really wasn't made to be on orbit for months and months and months with people in it. We worked a lot with Marshall. George Hobson was the Marshall responsible manager, and we worked a lot with him on the thermal control.

That's sort of the three areas that I've always worked in: the thermal control, the life support, and the spacesuits. I actually started in thermal control. That's where I started in Langley [Research Center, Hampton, Virginia]. We always worked all three of the areas.

NASA had a shuttle flight to Marshall in those days, it went—I've really forgotten, but I think it went up in the first of the week and came back at the end of the week. It was an Electra; it wasn't a very good airplane, not a very safe airplane, but we flew it a lot back and forth to

Marshall. It would land at Redstone [Arsenal, Huntsville, Alabama]. You'd land inside the fence. You could get in and out without airports and taxis and everything else. It was a good way to work, but you'd get tired of riding in a plane.

WRIGHT: Yes, I can't even imagine. Also in the late sixties, in the midst of all else that you were doing, you opted to get a master's degree from Rice [University, Houston, Texas].

GUY: In that era anyway, everybody's dream was to get an advanced degree. Langley had advanced degree programs that were taught on-site. I'm not sure where all the professors came from, but Virginia Tech [Virginia Polytechnic Institute and State University, Blacksburg, Virginia] provided some of them, I know. But you could take classes on-site.

I wasn't really very long at Langley, but when we came here, both Rice and U of H [University of Houston, Texas] were very interested in NASA, and Rice didn't have a scholastic bureaucracy then. Probably still don't have as much as other places do, but basically they did their own thing. You couldn't pay them to go there, because they picked who they wanted, and everything was scholarship, so they sort of did their own thing. But they were interested in working with NASA. Several of us went there and got our degrees. We would have to, of course, drive down there, take a class or two, and then drive back. But it was just sort of the thing to do in the time.

WRIGHT: Let's, if you would, talk a few minutes, about the start of the Moon missions. Of course, [Apollo] 7 was successful, and 8. Many people have talked about what a bold decision that was. Can you tell us your thoughts about Apollo 8, and then maybe talk a little bit more

about the missions and where you were, especially when they landed on the Moon for the first time?

GUY: You'll have to remember that Apollo 8, I was less than ten years out of school. I didn't really have a really global perspective.

From my perspective that was the first mission we flew the new radiator design, and as I mentioned the first time we talked, that basically was a NASA problem. If it worked, it was our glory. If it failed, it was our problem, because we had gone against the prime and said, "No, don't do it your way. Do it our way." We were very, very interested in whether it worked or not. My focus really was not really on [the flight] because the hard parts of that mission were not the life support or the thermal control, even though that was a brand-new thermal control device.

The hard parts of that mission were the GN&C [Guidance, Navigation, and Control] parts of the mission, the precision that you would have to have to be able to go and come back, and the accuracy with which you'd have to make your burns and all that. But that really wasn't my responsibility; I always had enormous confidence that everybody could do their job. It never crossed my mind that they couldn't do their job. If we were going, it was okay.

WRIGHT: Tell us your thoughts when Apollo 11 landed, and you were able to see your work come to [fruition].

GUY: It was almost ten years of "this is what we're doing." People talk today about getting a vision, and it will be wonderful, and of course, every company and every agency wants a vision.

They don't even understand. It's not having a phrase. It's a dedication. That's just what you did every day. When it really happened, it was extremely rewarding.

By then, of course, as I think I also mentioned, we had what's called a Mission Evaluation Room, where all the engineering people were housed during the mission, and you had a three-shift coverage, of course, and I always had one of the shifts. From the very beginning, I had one of the shifts, except for Apollo—I don't remember. It must have been 9. "Rusty" [Russell L.] Schweickart went outside. The life support was understood and functioning, and we were doing well there. We had a lot of trepidation about the water boiler up front, but we had solved that problem, and it turned out we had, so that was good.

But the radiator really came into its own on Apollo 8, and by the time we got to 11, except for Rusty's EVA, which was really a little "poke your head out" EVA; it wasn't really a lot of stress to the system or anything, because it used the vehicle's life support system. It didn't have a backpack.

[Apollo] 11 was the first showcase of the surface EMU, and by then we had developed a second capability over in the Mission Evaluation [Room]. It was pure EVA, and I had moved to that responsibility. I gave up my shift work and moved to that responsibility. When we were on the surface, I manned the Mission Evaluation Room for EVA. Of course, that was a double emphasis on the fact that to put your foot on the Moon, you had to be wearing the EMU. It was really an important milestone. It was sort of the culmination of almost ten years of making it happen, it was a really emotional time.

But we were as surprised as everybody else at the mobility concept, the hopping around. We had no idea that that was going to be the way in which astronauts found easiest to move along. We knew that with the low gravity, but everybody thought it would be long, graceful

steps, not the bunny hop. [Laughs] But that turned out to be the easiest for them to use. They developed it early and used it throughout all the missions.

WRIGHT: Did you have a chance to talk to Neil [A.] Armstrong and "Buzz" [Edwin E.] Aldrin [Jr.] when they got back so you could personally hear what worked well?

GUY: A little. Actually, they were national heroes. It turned out I knew Mike [Michael] Collins better than any of the rest of them, and he, of course, wasn't a surface astronaut. But he and I talked some, but only a very quick—we went to the debriefs, of course, and heard about the mission, but not really anything personal with either Buzz or Neil.

I did know Frank Borman, though, and after the Apollo 8, he and I talked about the radiator system.

But I don't have a lot of familiarity with when the [Silver] Snoopy, [NASA's Manned Flight Awareness Award] system started, but it was sometime toward the middle of the Apollo development. I don't really know when it started, but it was pretty informal in those days. It wasn't an official award that you get nominated for and whatever else. It was whatever the crew decided they wanted to do. I remember that I got my Snoopy for the EMU.

Mike [Collins] signed the letter. It was nice. I did get the other two to sign it, so I have three signatures.

WRIGHT: That's great. What an honor for that, especially from that historic mission. I had read where when Pete [Charles] Conrad and Al [Alan L.] Bean came back, they had made a couple of suggestions for the next crew, which included a drinking pack, because they said they got thirsty

when they were on the Moon. Do you recall them making that suggestion and other types of suggestions that other crew members made?

GUY: No, Jim McBarron could explain that to you. We did have a drink bag. I didn't know when it started or what the first mission was. But the most publicity we got was that somebody wanted Tang, and the Tang leaked, so that was a mess.

But again, McBarron would be much better at remembering that item. I didn't have anything to do with the drink bag.

WRIGHT: Okay. I was just curious on when they [the astronauts] brought back suggestions, if all their suggestions seemed to be workable.

GUY: The crew had a lot of good experience that we were able to use. There was always a debrief, and whatever suggestions were made, we always took a look at. Also, pre-mission the crew had some special requirements sometimes. I think it was Dave [David R.] Scott wanted a harness built for his backpack so he could carry tools, and one of the crewmen wanted a sort of a golf-cart-looking thing. There were always crew inputs that always got a lot of respect. The crew had a lot of political power. They not only were important in that they were the user, but they had the political power, so as far as I know, whatever they said was always considered.

WRIGHT: Talk about the assistance that your division gave with Apollo 13, in rescuing the crew.

GUY: Again, the big-picture problems were taken care of by other people, and we had total confidence that they'd take care of it. The big-picture problems, they obviously had lost the oxygen tank. There wasn't any real understanding as to what the implications of that was going to be, but if you needed oxygen you could find some in the Lunar Module, and if you needed power you could find that in the Lunar Module. When you finally had to separate from the Service Module—that's where the explosion was—and come home, well, the Command Module had to bring you home, obviously, and there was a lot of concern about making sure the explosion hadn't harmed the ability to do that.

But basically our job was how to get rid of the CO_2; you can asphyxiate yourself so you had to get rid of the CO_2. We couldn't run the Command Module, because that's where the major lithium hydroxide was, and that's where the crew was supposed to spend most of their time, in the Command Module, and only two days, two crewmen in the Lunar Module. We've got three crewmen, and we've got to go all the way to the Moon and then all the way back. The two days are not going to get you there; you've got to find a way to use the other lithium hydroxide.

We took all of the onboard stowage items that we thought could be useful and created an adapter for the canisters that were going to be used in the Command Module so that they could be used in the Lunar Module, or they wouldn't fit. We used covers from procedures. We used plastic. We used tape that they had and created some ducting systems that would let them use that lithium hydroxide. That basically worked and got them home. It was a very uncomfortable flight, though. They had almost no thermal control. They had very, very, very little power. They couldn't run hardly anything. It was a terrible flight, but survivable. That's the part that we did.

WRIGHT: Thanks to Ron Howard and Tom Hanks, we all have a visualization now, thanks to the movie, [*Apollo 13*]. But is that pretty much what you see happened is what we now see in the movie, or was it more complicated? It almost seemed so simplistic.

GUY: They modified; they had to adjust the character base, I think. The person that actually, I think, was given credit for the lithium hydroxide adapter was, I think, an MOD person, which was not true. In fact, all of the testing and evaluation that we did was not in the movie, either, because, you know, it wasn't germane to the main plot line. They were developing the plot line, which was, fear and trepidation. That part really wasn't realistic.

My boss, Ed [Robert E,] Smylie, was really the face. He was the one that took the challenge and led the team and built the hardware, did the test, and then took the answer back. He was on, I believe—I'm pretty sure—he was on the staff of our division. We had an assistant chief for Apollo, assistant chief for Skylab, and he was the assistant chief, Apollo, I believe, at that time. He was the senior person and the rest of the team, we provided suggestions and test support and whatever was necessary, and there was a building full of people during that time.

WRIGHT: The remainder of the lunar flights seemed routine to the American people, but were they all the same? I know that we had specific instruments, [as you mentioned] Dave Scott with the tools, and various objectives on various missions. But did you notice a lot of changes and a lot of evolution from the first to the last lunar mission?

GUY: I think the vehicles were roughly the same. The big changes were the Lunar Rover, when it came on, gave them tremendous distance capability to get away from the vehicle. We did develop a little "buddy" adapter, so you could use one backpack for two crewmen, so if while they were away from the vehicle, something happened to one of the backpacks, that they could be attached. I don't even remember what the acronym stood for, but it was called a "Buddy Sliss." That would be Buddy SLSS—Suit Life Support System? I don't know what it stood for. But it was an ability [for] two people surviving off one backpack.

That was another problem. The only reason you could do that was because we had external connectors, and of course, the Shuttle has no external connectors, which is a good thing, because that puts bunches of hoses and things to get snagged and things to be getting away. You also had to put on the backpack like it was a rucksack, and it had to be adjusted. Since the controls were behind you, it had to be adjusted that you could reach them. For some of the crewmen, depending on their arm lengths and their suit sizes and all, some of it was very difficult. The backpack had to be positioned to one side so that they could reach the controls. They had most of the controls on the chest. Again, I'm not sure what they called it, display module or control module. But the water controls were on the back; they had to reach back to do those.

WRIGHT: There was a time period where the Apollo era was moving to its end, and you were preparing for Skylab. Then also announced was ASTP [Apollo-Soyuz Test Project], and then Shuttle was approved in early '72. You have all these different programs that are somewhat unique in their own right, and you were having to provide testing and development process. Can

you share with us what that was like at that time period, and how all this was getting done within this division and on schedule?

GUY: As I said before, the vehicle was not our vehicle. The main vehicle was Marshall's, and they outfitted. They did the outfitting. The one thing that we did, we had all the doctors in our division at that time, so we did a long-term, fifty-six-day test of the Skylab life support system with crew. We locked up the crew for fifty-six days, and I think all of them were crew; I think all the subjects were crew. There were, of course, a lot of medical parameters evaluated and the recreational aspects and the health and all the rest of the stuff. We did that as a test job.

But other than that, the activity was mainly suit focused. We did use, in large measure, the Apollo suit, but there was a need to go EVA with a much longer umbilical system. Gemini and Apollo 9 had just sort of stepped out the door, but they needed to go actually do some EVA missions. We had to develop a portable device that you wore like a fanny pack on the front and long umbilical systems and everything. Those were developed as part of our EVA life support capability. There were changes to the suit. I don't really recall many of them, but as I said earlier, the life support added to the spacesuit made an EMU, and there was a Skylab EMU, and we did the integrated testing and analysis.

I really hadn't mentioned that very much, but my earliest career in the space world was very analytical based. The need for and the use of analytical tools and analytical techniques was a very strong part of my early involvement. I think I mentioned last time the thermal control system for the Apollo vehicle when we thought the Command Module was going to land; the Lunar Module hadn't been thought about then. I did all the analytical work associated with the designing of a radiator system.

That evolved on. At various other early times in my career I had always had an analytical group or section, and then sometimes I had a technology group that also did the analysis part. But always, no matter what organization I was in, the analysis part of our division I was responsible for. Even one time I was a staff office, directly on the staff of the Division Analysis Office. We had developed both thermal control analysis tools, fluid flow analysis tools, process analysis tools for analyzing chemical processes. A lot of analysis was going on. For the Gemini radiator system, we did the analytical models of the Gemini radiator system. For the Skylab heat rejection system, we did all the analytical models of that. We had that aspect.

We did the test management. Again, as I think I explained last time, which meant that I didn't have direct control of the facilities, but we would do the test planning, the test cases, the pretest predictions, and then we'd run the test; make the calls for test deviations, changes, depending on what we were finding out. Then we evaluated test results and put out the test report. I didn't have the facility, but I had responsibility for the test itself, which, as I said earlier when I said I tested, or we tested, the EMU at the Chamber B.

Actually, Chamber B was not even owned by our division. It was owned by the Spacecraft Environment Test Division, I think it was called, SETD. It had both Chamber A and B and Building 33, which has all the small chambers. We came over and contracted with them to provide the facility, but then we brought the test articles and we brought the test plans and everything. It was our test. But as you go through, there were a lot of analytical responsibilities that we had with respect to the new vehicles.

You mentioned Apollo-Soyuz. We conceived of and developed and contracted for the transfer tunnel, the device that allowed the five psi [pounds per square inch] pure oxygen

Command Module to interface with the Soyuz, which was two-gas atmospheric pressure. There was a lot of analysis done on that. Jim [James R.] Jaax was dominant in doing that work.

As Shuttle came along, we did a lot of pre-analysis and a lot of technology work associated with the systems that were going to end up on Shuttle. We built the radiator systems. It was a new kind of a radiator, a two-sided radiator system, many, many, many tubes. I think I mentioned to you before the tubes were the death of the original Apollo radiator. They were not configured right, and we used the tube configuration, although it was minimal—there weren't very many tubes, but a few tubes—as a design function for the Apollo radiator system that went to the Moon, Block II.

But we learned enough to know that we'd never do that again. We changed fluids and went to a different kind of radiator. But again, if you've ever seen the Shuttle picture with the door opened, it's got four very large radiators on the inside of the door, and the front four are actually two-sided radiators. They can lift off the door, and you can expose the bottom side. We did all that work here and did the technology and, again, tested it; that was in Chamber A. It was probably the most sophisticated large-scale test ever run in Chamber A, with the exception of the vehicles, of course; they had a Command Module they put in there and a Lunar Module. But in terms of a system test, it was a very, very sophisticated test.

We did all the technology work for the flash evaporator, which was, as I said, we didn't like water boilers, so we got away from those and went to a new concept. We did all the technology work, all the analysis, and then we did end up testing those here. That period of time was really a lot of conceptual work, a lot of analysis, a lot of technology work, because our basic flight work, we weren't as much hands on. The Skylab, as I said, was basically a Marshall vehicle. They managed the main contracts, and we were in a support role.

Of course, that was very early for Shuttle. Apollo-Soyuz was really a big event personally for me, but not really a big event for the division. We did do a test of the transfer tunnel over in the eight-foot chamber within the division, but again, that was not a very sophisticated test. We also tested it here in Chamber A, too. But that did not warp the focus of the division very much, Apollo-Soyuz, because it really wasn't much about changing up our hardware. It was putting an adapter on, that could be the transfer tunnel. Our hardware was the same. Apollo was still Apollo, and so it was not a big focus job. We didn't redesign the suits or redesign the radiator systems or anything like that.

WRIGHT: Before we get into a lot of detail about ASTP, I wanted to ask you, because the analytical and the conceptual work was so vital to the future, what type of people and what kind of qualifications were you looking for when you were building your team, when you were hiring in new folks?

GUY: I don't think there was a set of requirements that say that if you're going to conceptualize spacecraft, you need to look like this. It's mainly just good people. I think the hiring restrictions that have come about over the years have really, I think, very detrimentally affected being able to keep a balanced workforce. You get in periods where there's no hiring, and then you get in periods where if you can do it in the next three weeks, you can hire, and if you can't, you can't. I think those have really tended to provide some imbalance in the workforce.

But we didn't have those restrictions at the time. You could really get good people. You could understand them and hire them because they had the kind of skills, the kind of capabilities that you needed.

By the time we had gotten to the early seventies, there was a technology organization within my branch that basically was responsible for all technology but suits, brand-new suits. The suit people did suit technology.

But we did all of the life support kind of technology, and that kind of person is a kind of an inward-focused person, a person that can worry about the science, worry about the engineering, worry about the theoretical aspects of a process or a concept, whatever it is, and work through the development and the problems that are associated with it. It's someone that it's not the classical scientist, because the end product has to be a functional piece of hardware. It's not just a proof of principle, but you've got to take it all the way to where it's useful.

I mentioned earlier being able to go to Bob Thompson and say, "You can come over and look at this thing. I mean, it's configured correctly. It will give you the right performance. We've already proved it for fifty-six days, and that's your mission." The first Skylab mission was [twenty-eight] days. That had to be an attribute; we did need some people that had a fairly broad span of the ability to look at the theoretical but also look at the practical.

From an analytical standpoint, that, again, is sort of a different kind of a person, because someone who can be challenged with an analytical representation of a system and evaluate that system through that representation and provide the fidelity, do the correlation with actual test data, conceive of tests that will give you that correlation, that's also a different kind of a person.

I think the more classical engineer at that time was the hands-on engineer. The computer age was just starting, and there wasn't an army of those. They were mainly newer, the younger, newer group. The older, experienced people, engineers, were in general hands-on engineers, good test engineers, good hardware development engineers, good design engineers, but not really

the forward-thinking engineer. The early challenge is that if you want the real answer, you test it. If you want somebody's guess, then you go get some analysis.

It took a while, but I think that, depending on how good you were, you could get early respect for your analysis, and I think that today that wouldn't be a challenge anymore. People realize that simulations can actually be more sophisticated than physical tests sometimes; that you might need to anchor your simulation, your models, with some test data, but the test data will likely be sort of in the middle of the envelope as opposed to the edges. You use your analytical capability to really fill out the envelope, and it's not as much challenge today.

In fact, the analytical sophistication that's needed for some of the thermal stuff that's being done today, you really couldn't do any other way. The wind tunnel data is so restrictive, because you get warped by the facility, you get warped by the configuration of the facility, you get warped by the fact that you're using a test article that is not the real thing, and everybody recognizes that the analytical side is a respected side of the engineering. But that, as I said, that really wasn't the case in the beginning. But it was interesting, a very interesting time.

Since I always had the analysis part of a division, I may have mentioned this last time, but I was always able to provide an internally focused configuration for computer support. We had the whole Building 12 was full of mainframes. We had direct access to mainframes from our location, and as time went on we had standalone capability. When we first moved here, we were in the Lane Wells Building before the site was built, and that was in '62, '[6]3, somewhere in there; we were on site in '64.I got my first computer for the division, and it was a 1401. I just remember the number. It was an IBM [International Business Machines] 1401. It was the first computer that the Crew and Thermal Systems had, and we always had a computer from there on.

We weren't completely a slave to the Building 12—well, it turned out to be a bureaucracy, but they were really good people. But it's like anything else. When there's a service that you have to have, then the service people get a lot of power; they had a lot of power. But as in anything, it's who you know. Create your network and you get people that will help you.

WRIGHT: You were talking about the engineers being able to produce functional products, and I know that in the early seventies that some of the fire safety garments that were developed were adaptable for the general-use market. Can you share with us how that came about?

GUY: I meant to mention something. Let me retreat on that subject. You can hold that subject. But flammability turned out to be a really big problem after the Apollo [1] fire. Fire, flammability, was a really big problem. There were spacecraft design solutions, and there also had to be solutions for fabric for clothing. I didn't have anything personally to do with the development, but there was a lot of materials development done for developing material that would not burn. We had a materials organization that did that, and they did some really good work.

But when Apollo-Soyuz came along, the Russians needed to visit our spacecraft, and we wouldn't let them in, because they didn't have clothing that wouldn't burn in 100 percent oxygen. That was no good, so they had to come up with clothing. We thought for a while we were going to have to provide the clothing, but they took the challenge and developed some nonflammable material. Of course, we insisted on being able to test it, which I was Working

Group chairman, so I got the samples and had them tested, and it worked. They had developed also material that wouldn't burn in 100 percent oxygen.

The materials world was always part of the division. You mentioned something earlier about the—it's called superinsulation. It's a multilayer insulation. When we had to cover such a broad range—the lunar surface can be from minus 250 to plus 250 degrees Fahrenheit—500 degrees is a tremendous range in thermal conditions. We needed something to insulate the crewmen from both the heat and the cold, and as I said, the spacesuit world in those days was pressure garments.

We decided to try something they were using on cryogenic tanks, which was multilayer insulation. We decided to see if we could create garments out of the multilayer insulation, and we told them how many layers they were going to have to have. Then, of course, when you sew it together, it doesn't operate as well. We'd have to do a bunch of testing to get past the seam effects. Every seam is like a heat short. If you can stay out in the open area, it works real well. If you get in the seam area, it doesn't work as well.

Well, anyway, we defined the design to be both the liquid-cooled, which I mentioned, and also put the multilayer insulation on the outside. Again, that was brand-new. Nobody had ever done that before. The vendors, they were bidding, of course, on their experience, and they had no experience with that at all. But they came through, and we had good thermal insulation all the way from Apollo.

Now, your question was?

WRIGHT: The adaptability for general use of some of the fire safety garments.

GUY: We developed after the Apollo fire the clothing fabrics that I mentioned earlier, but we also developed a cloth made out of glass, Beta cloth. It has a Teflon coating on it to keep it from shedding, but it's basically glass; glass is silicon dioxide. You can't burn it, because it's already oxidized, it's absolutely safe. You can melt it is all you can do to it, and glass melts very hot. It was a very safe material. It's not really terribly durable; it did have some issues, but it was a material that you could totally depend on to be flammability resistant. It would not burn under any circumstances.

That material has had some use as well as some of the other nonflammable materials. They've used them in some fire safety type applications. One of the Skylab materials was a material called Durette, which was a nylon derivative, and they've used that, or used to use it, in some race car driver outfits.

The other application that I can recall is, because of the backpacks, we looked at helping some firemen with a lighter weight backpack to carry oxygen and a better mask and some flame-resistant clothing, as sort of a spin-off activity. I didn't really have anything directly to do with that. McLaughlin—can't think of his first name. Anyway, McLaughlin was his last name. He was the Project Engineer on that, he developed that, and it got some play for a while. I don't know how much of that is still used or not. Maybe it's all still used; I don't really know. It was a spin-off.

WRIGHT: When you began your career with NASA, the United States was in a race with the Russians as to who was going to land on the Moon first, and then here in the mid or early seventies, we began having a working partnership with them. Do you recall the first time that

you heard that ASTP was going to be a program, and how you were going to be involved, and what your thoughts were?

GUY: I'm trying to answer the thoughts. I don't know that it looked like anything more than just a new adventure. I didn't have the political concerns that I think may have existed at the time, that we were going to give away a bunch of secrets. We each had our own spacecraft, and I never really thought that was an issue, and I don't think it ever was an issue.

But from an adventure perspective, I think the idea of dealing with basically the only other space nation in the world at that time on a one-to-one basis was a really exciting prospect, and I mentioned Ed Smylie first. He was now division chief. I think he was now division chief. But he was named to be one of the group that went over there on the first trip that was made to Russia. At that time, I'm really not sure how firm the mission was at that time. It seemed to me that there was still some variability as to exactly what the mission was going to turn out. But anyway, we did all the prep work to give him material to send with him, and he basically was the only person from the organization that went.

Then the next meeting was here—they alternated sites—and then we put together our team and supported him here, and I think—I believe Jim Jaax was involved. If not then, at least the next meeting he was involved in, but very early, and several other people. We had thermal people represented, Tommy [J. Thomas] Taylor. We had Will [Wilbert E.] Ellis, who was also thermal and test; Will did all my test planning and all my analysis work was done by Will. Dick [Richard E.] Mayo, he was the subsystem manager for the Lunar Module. This was many years later, but that was his background, and he was a part of the trip that we took to test the hardware in Russia. He went on that trip. Bob [Robert L.] Grafe did a lot of operational work with us.

I can't remember all the group, but basically it was a team of people that we began to design what the vehicle looked like, and pretty much Jim Jaax and I, maybe with Will, pretty much figured out what the transfer system was going to look like and how it was going to work. Then I believe it was the second trip back to Russia, I had been named as Chairman of Working Group 5, which was the Crew Transfer Working Group, and took a team of four or five people with me. Then we cycled back and forth. I don't really know; it seems like I went five times, but I don't recall that precisely. I think it was five, though, and there was always an alternate trip here.

We went all the way. We tested the hardware here and both in the eight-foot chamber in Building 7 and also in Chamber A in this building. Then we tested the hardware in Russia. We went to an Air Force base there; I don't even remember the name. I'm not even sure I ever knew the name. But anyway, it was tested in one of their facilities. That was a really good experience. That was really the only time that we ever really saw—we were always in office buildings and all until then, but we saw their test facility.

I guess the overriding conclusion that we drew is that they were a lot less—I don't want to say this in a condescending way, but a lot less sophisticated. Everything was very rudimentary. No frills, and a lot more faith as opposed to proof. We had a lot of discipline early to prove that what you believed was true was really true, and it seemed to be a lot less of that.

They were, of course, exceedingly secretive about their systems, and since we had to interface the two vehicles together, we needed to know a little something about their systems, and it took a while to pry that information out. We weren't interested in secrets, but they considered things secrets that I never would have considered secrets.

It took us two meetings, I guess, maybe more than that but at least two meetings, to find out that they had no makeup nitrogen; that they basically closed the door, and whatever nitrogen was in there, they took that to orbit with them and brought it home with them, and if you had any leakage, you just made it up with oxygen, and you didn't worry about the nitrogen. We didn't know that. We were talking about depressurizations and repressurization between the two vehicles, and we assumed they had a tank of nitrogen, and they didn't. They didn't want any part of mixing the vehicles up, because they couldn't make up the nitrogen.

Obviously, there's no reason for that to be a secret. It was just a characteristic of the system that they didn't carry nitrogen with them. Actually, it was a good characteristic. Their vehicle was so tight that their leakage was so small that they didn't really need any makeup. But we didn't know that. But anyway, there were a lot of things like that it just took a long time to get all the details out so that you could make the system work.

WRIGHT: Was time the answer that built the trust, or how were you able to have them trust your questions?

GUY: We always had very good relationships at the working level. We really never had any issues at all. But I think—it was our opinion—I don't know whether this is true or false, but there always seemed to be a person that didn't participate very much and didn't seem to have any natural expertise, and we always assumed that that must be the watcher, the KGB [security agency of the Soviet Union] or whoever that was watching things. I think they were dancing around that more than they were afraid of us. At least that was my perception. Because

sometimes, you know, when you'd be away in a social event or something, sometimes you could get a lot better insight than you could in a formal meeting.

But it was really a very interesting time to—it was right in the middle of the Cold War—to take the challenge to cooperate; to make sure that each side did what they said they were going to do, and that your designs integrated together. Of course, I think we had sort of the glory part of that, but probably not the technically difficult part of that. Obviously you had to get a rendezvous, and you had to have docking systems that mated, and there were some really tough technical problems. Ours was basically common-sense engineering and just make sure we had a design that was very reliable, very forgiving in terms of misoperation and all. And we did; we had a really good design.

WRIGHT: Did you have any preparation from, not necessarily NASA, but from government officials giving you instructions on what not to do or to do once you traveled to Russia?

GUY: I'm sure we were given some sort of a briefing, but it was so insignificant I've lost it in my memory. But there was nothing given that did anything to your behavior that common sense wouldn't have done naturally. We obviously didn't want to give an edge to the Soviets in anything that we did or saw. They wouldn't let us see secrets, and we didn't let them see secrets. But that was expected. I don't think there was any issues. I never saw any issues there.

After the first trip—I think it was the first trip—I did go to the Pentagon, the one and only time, for a debrief. I answered their questions, but I don't remember knowing anything of any significance, or if I did know it, they didn't react so I could tell, so I don't know. [Laughs] That was an interesting experience, to go to the Pentagon, though.

WRIGHT: I can't even imagine that. Can you share with us what it was like for you?

GUY: It was not very dramatic. Basically, we were escorted with escort badges directly to a conference room, a debrief room, where we met with whoever they brought in to talk to us, and we were escorted back out. The Pentagon's a very big place. I didn't get much of a feeling for the site. But, as I say, it was an interesting experience.

WRIGHT: What about your travel to the Soviet Union? How long were you there? You mentioned some things about social aspects of your interaction with the Soviets.

GUY: We were super lucky. Actually, the reason everybody thinks it was so hard was a blessing for the tourist part, because they were having no tourists. There weren't any tourists in Russia, so we were an oddity.

Like when we went to the main museum in Star City, maybe—I don't know where that was—there was nobody there. They had to turn on the lights for us so we could walk around and look at the Soyuz vehicles and all of them. There was nobody there. We could get perfect seats at the Bolshoi Theater. We were escorted to Rostov, which was one of their hero cities, and entertained there one day. We had a private tour of the Kremlin Museum.

I mean, we were an oddity. When we were in the minivans or the buses, there would be a police escort, who didn't stop for anything or anybody. We just followed them. It was amazing. My first trip, they took us to St. Petersburg; Leningrad, I guess in those days. Spent a weekend

there as part of the deal. It was really nice. Went to the [State] Hermitage [Museum, St. Petersburg, Soviet Union]. How can it be better than that?

It was just unbelievable how noncommercialized, or whatever the word is, that they were. They made the arrangements for the tickets. They made the arrangements at the restaurants for us. If you wanted to go someplace or see something, you'd tell the Intourist. They call them Intourist; that was the government tourist agency. I guess they must have had some tourists or they wouldn't have had a tourist agency, but you didn't see any tourists. It was interesting.

They told us, "Don't exchange money." They said, "You'll be accosted on the street to exchange money, but don't do it, because they're not allowed to have anything but rubles, because if they have anything else, they can black-market it. The ruble is not internationally traded. They all wanted dollars to go to the black market and buy something." And they said, "You don't want to tangle with the legal system here; don't change money."

But the people were nice, even the citizenry was nice. Like we went to bookshops, about the only place where you could get something that had some kind of an international flavor to it. There would be a student or somebody there that could speak a little English, and they'd always be glad to help you.

We'd go to the big galleria kind of a [shopping] place; it's called the GUM [Gosudarstvenny Universalny Magazine, or State Department Store]. We went to the GUM to do souvenir shopping and stuff. Everybody was friendly. I guess the GUM is still there. It's been a long time since I've been there, but it was like a three-story, maybe four-story shopping mall with an open center area.

But there they had very little merchandise of any kind. They would set up displays in the window. There was a display department, we were told, and the display department put stuff in

the window, which you couldn't buy, because it wasn't in the store. It had nothing to do with what's in the store. It was a window display. You couldn't say, "I'd like one of those."

Doesn't work, you know. "We don't have that."

You'd go to the grocery store, and you would see empty bins everywhere. There might be some cabbage and potatoes and beets, and that's about it. I mean, nothing else, the whole store. Just amazing, the lack of products that were available to the people, and that created a culture of shopping. They carried what we called a "maybe bag." I don't know what they really call it, but it was a fishnet kind of stretchy bag, but it was only a bag if you opened it up. Otherwise they'd just stay wadded up in your pocket. We called it a "maybe bag" because all the people, when they would walk down the street, they would go into the shops and then back out. That's the way they walked down the street, because if you saw something, right then you bought it and put it in your "maybe bag" and took it home.

The worst example I ever saw of that was in the GUM. That's the reason I thought of it is that we saw a line of people down on the first floor, winding up the stairs, second floor, third floor and down, but we couldn't tell where they were going. We said, "We have got to see what all these people are standing in line for." We traipsed upstairs. It was a shoe store, and we said, "What are these people buying?" We just waited, and they were buying purple plastic rain boots, you know, the kinds that little kids wear. That's what they were buying, and there was a line—it must have had 150 people in it, maybe 200; lots of people.

I said to the person, "Now, why would anybody stand in that line for purple rain boots?"

And they said, "Well, if you don't get them now, you never get them. They won't ever have them again."

It was an interesting time, but in the GUM, for example, you'd see one washing machine. If you wanted a washing machine, that's the washing machine, and you bought it. Otherwise you'd do it by hand.

Only one of the people in our Working Group had an automobile. It was an old one, too. He was the Chairman of the Working Group; he had an automobile. The first day when we got there, he met us at the airport and picks us up. He met us inside, of course. We went outside, and he picked us up and was going to take us to the hotel. He was really proud of his car, because he was the only one that had one. But he picked us up—and it's snowing—before he gets in, he puts his windshield wipers back on. He had them in his pocket.

Of course, we said, "Why did you do that?"

He said, "Well, you can't buy them, and if I leave them on there, somebody will steal them. I have to keep them with me when I park my car, because they're not purchasable."

When they came here, we took them to shop, and they'd buy strange things. They would buy chimneys for Coleman lanterns. You know what a chimney is? The little fabric thing that you put in the lantern —and they would buy shoelaces. They would buy—they loved jeans. They bought lots of jeans, but things that seemed sort of out of place. Like why would you want that? And it was because of the demand. I guess, since it was a government-owned manufacturing system, they only built what the government said, "Build," and shoelaces weren't on the list, and "sorry about that."

It was an interesting time, though. You mentioned social. There was a deal—I don't know if they made it up or we made it up. It was already in place when I got there. But at the end of each visit, they would host a little get-together, and at the end of a visit here we'd host a little get-together. Only one time did we have it in one of their apartments. They all live in

apartments there. The only way you lived in a house is if your parents had had the house and died, and you got the house. Otherwise, they didn't build any houses. They only built apartments.

It was extremely stark. The fellow was really nice, but it was extremely stark. But they would have a place, a restaurant or some place they would have, and they'd always give you a little gift, a little *matryoshka* doll or something, whatever. Then here, of course, we generally went to one of our homes and had the going-away deal. Sometimes they would have a big group going-away deal for not just our Working Group, but for all the big group, and of course, we went to it when they had one of those.

But they'd come to your house and enjoy. They brought a soccer ball for my son, and got out in the yard, and they thought—I guess they thought—everybody played soccer. My son hadn't started playing soccer at that time, but anyway, he enjoyed kicking the ball. They brought little gifts. We'd have a meal and whatever. It was always very pleasant, very social.

They did like to drink, though, lots to drink. But it was plentiful. They had a lot of vodka. I guess it must not have been very expensive. I never bought any, but it must have not been too expensive, but I guess they didn't have to pay for it, because it was a government deal; it was given to them. Maybe that's why they drank it. It was free. I don't know. [Laughs]

WRIGHT: Well, on that thought, let's just take a break for just a second. I want to change this tape out.

[Tape change]

WRIGHT: We were talking about ASTP. Share with us how you felt the Soviet workers and engineers adapted to the United States' way of doing business.

GUY: Well, I think adapted might be the wrong word. I think we each did our own thing. I think that after a while they tolerated our being so inquisitive. We were never comfortable with just a statement that something was true or something would occur. I think over time they ended up understanding that that was sort of a necessary part of dealing with us is that we'd want that extra assurance.

I never really thought that the people we worked with had any issue with providing us that assurance, but I think in their culture, and I still see it in Space Station today, in their culture they really don't like a "prove it" type challenge. They are independent and act independently, and so there are a lot of times even today that we are unable to penetrate to get enough information to make decisions that we think are prudent.

But I think at the individual level, I think it's usually workable, but I think it is a cultural difference that still exists; we didn't break down any barriers or anything. I think they tolerated us as opposed to adapted to us. We had a good relationship with them, but it was different.

WRIGHT: Can you talk about the Working Group system and how that worked in making the ASTP successful?

GUY: Actually, I don't know who thought that up, but it turned out, particularly in hindsight, that that was really a brilliant move. It compartmentalized the problems into a set of problems that a small group of experts could work, and I think by doing that, we didn't bleed over into

generalizations and into unfocusing discussions and action items and whatever; that if you try to cover everything together, then you're forever tripping over another aspect of some other problem that appears to be interfacing with what you're working on. It was a small group. The group that met probably was never more than—I don't have a crisp memory. Five or six or seven on each side was probably as many as ever met together. Probably more likely five-ish would meet.

Of course, we had to get from beginning to end; there were certain things we had to agree on, like the configuration of the transfer module. Just the normal prioritization thinking of what do we need to get done early-ish, early. We had to get the thing built. We had to get it agreed to early as to what it was going to look like. There were those kind of pressures, commonsense kind of pressures that prioritized things, and we'd set up the agendas, and then we'd meet. As I said, we rotated. Every other meeting was in the other country.

The meetings were generally two weeks long. We would have, as I said, an agenda and generally the meetings would start off with some presentations of whatever the subject was. If it was a design subject, then maybe some schematics, some candidates designs, some explanation of why that might be a good design. Then that would lead to discussion of why a change in that might be better.

Everything is slowed down double, twice. The first time because everything you say has to be translated, so that's the first; doubles the time. Then you double the time again because the translators did an English-word translation, and meaning does not always follow with English-word translations. Technical discussions don't directly follow English-word translations. You would end up with confusion. You would generally end up clarifying whatever you said, which went through the translation part and then, hopefully, then the clarification part.

Progress was very slow. You would think in two weeks you would get a lot done, but you really couldn't get nearly as much done as you wanted to get done. It always was very frustrating when—you've probably seen the silhouette that was used in the psychological evaluations where, if I tell you it's a goblet and show it to you, it looks like a goblet. If I tell you it's the faces of two individuals staring at each other, that's what it looks like.

WRIGHT: Yes.

GUY: That same kind of thing would happen; is that all the facts were okay. Everybody absorbed the information okay by looking at the silhouette, but their perspective and our perspective were just different, and we would end up taking sometimes hours before we figured out what the difference was. People just keep adding to the database they have and not necessarily seeing that there's a big disconnect here; that all the facts still match, but it's just the wrong answer. It's a different way to look at it, and we would spend very frustrating times sometimes trying to understand what the other one was saying and just not being able to get there.

We had varying degrees of familiarity with the natural, native languages in our interpreters. One of our interpreters was, in fact, an engineer, so he had pretty good ability to take engineering stuff and translate it. The problem he had was that he had been away from Russia so long that he wasn't very good in Russian. He understood and he was trying to communicate, but by the time it got across the barrier it could be just as confused as somebody who didn't know engineering at all.

Then on other occasions, we had one Intourist translator that was really very good. We had one—I think she had been in the U.N. [United Nations] as a translator part of the time, and she could simultaneously translate, which sounds really good, doesn't it? Wrong. She only understood the English. When she translated, and she did it sort of unthinkingly, she would hear and talk sort of at the same time. She wasn't forming thoughts and then transferring the thoughts. She was translating the English.

Of course, the Russian sentences are all backwards from ours, and they don't string adjectives together, and there's all sorts of things that make just an English translation a poor way to communicate. Despite the fact that she was really a superb translator, sometimes that would get us all in trouble, too. Things went slowly. I don't know how I got off on this, but progress was not fast.

As I said, I think I took, I think it was, five trips, and they were two weeks each, and there was an equivalent, I guess, five visits here. Some of the more interesting ones, I mentioned the testing we did. It was on an Air Force base near Star City. That was really interesting.

But the Flight Readiness Review process was really a very interesting time. George [M.] Low went to Russia and sat with—I don't remember who the lead was in those days. They changed leads along the way, I think. I don't know, but anyway, he came over and the Russians had their own senior person for the Flight Readiness Review, and all the systems people had to make presentations on their systems and get it blessed off by the Flight Readiness Review people.

I put together the presentation and gave the one on the transfer module and the design, why it was the way it was and what testing we'd done and everything. That was really an interesting meeting. My part, as I said, mine was more commonsense engineering than technical

sophistication, but we had a very good commonsense-engineered system, so it talked well, explained well, and we'd done the right kind of testing. It was a good time for us. It was very interesting, a very interesting meeting.

We did go back after the mission, sort of a debrief. That was a little sad. It was all over. [Laughs] But it was a very interesting time.

WRIGHT: Where were you during the mission? Were you here?

GUY: Yes. In fact, we did have some people over there, but they had the main team, or what I would call the main team, here. Jim Jaax was the lead. They had a little special room right off the main room in mission control over there, and we had a couple of the Russians that were there. [V. K.] Novikov, I know, came. I can't remember who else came; several of the Russian people. Then we had some people over there. Bob Grafe was out of my group; I think he was over there. But anyway, they had them in both control centers, yes. Of course, our system didn't have any trouble, so we didn't really have any issues.

WRIGHT: The NASA transfer tunnel was very vital to this project.

GUY: Oh yes. It had to work, all right, but it was not a sophisticated design. It worked fine.

WRIGHT: We mentioned just a little while ago about how so much was always going on in your division, all the different areas, and ten weeks of being in Russia and then, of course, things were here. What else were you working on? Was this the only time in your life you were working on one thing or one project?

GUY: No, actually, we weren't working on one thing. Actually, between trips, there was a fair amount of time. I don't even remember the cycle, but there was a fair amount of time between the trips. I would say—you're going to have to go back and check Jim Jaax's notes, but I think during this time there were several periods that he probably was wall-to-wall between the two meetings. When we got into the testing, again, Jim and, I think, Will Ellis was involved in the testing, and again, there were probably periods that they were pretty much consumed.

But they were just members of the branch, and the branch had a lot of work to do. I got to be part of the planning and the review part of the activity. And as I said in the very beginning, the actual design of the transfer module, I think Jim and I worked that out ourselves. But again, his notes would be much better than mine. He was very integral with all phases of the activity.

WRIGHT: All right. We were going to shift over to the Shuttle, but were there other aspects or areas of work that you did or some other projects that you worked on during those first twenty years?

GUY: I mentioned earlier the fact that we thought the space program was going to be pretty fast paced. We actually began in the mid-sixties doing regenerative technology for life support, ways of collecting CO_2, of cracking the CO_2 back to carbon and oxygen, to disassociate water back into hydrogen and oxygen, to collect waste, to incinerate waste. We did a lot of technology work associated with Space Station and Mars type missions.

In fact, the way technology was done in those days is that we had a part of the agency that basically had technology responsibility, and we would compete for technology funding, and

then if we got the funding, then we'd issue contracts, competitive contracts, for whatever we were interested in. We did a lot of studies. We did a regenerative life support study for Space Station and one for Mars mission. I remember those were two separate studies. We did a lot of technology testing. We'd build subsystems and bring them in the lab and test them.

We did a lot of integrated system testing, although in the very early days Langley did the integrated testing, and then they got out of the business. They didn't stay in the life support business very long, but they did a lot of integrated testing. Then later on we did the integrated testing here. I believe one was done at Ames [Research Center, Moffett Field, California], maybe, or somewhere out on the West Coast. Maybe it was MacDac [McDonnell Douglas Aerospace Company]—I mean McDonnell Douglas; in those days it was just McDonnell, I think. That doesn't sound right. I don't know. I think it was done at the West Coast, though.

But there was a lot of getting ready for the future, which it turned out the future was a lot further off than we thought it was. But the thought was after Skylab that we'd build a Space Station. I think most people thought that. I think [Maxime A.] Faget had a different idea, and he was successful in selling the Shuttle, but I think most everybody thought that Space Station was the next thing on the agenda. Of course, the Soviets had their Space Station, and the old competition spirit said, "If they've got one, we ought to have one, too." We went toward that as a goal. As I said, the technology money was available to work on it, and we had in-house facilities and test capability; analytical capability, too.

We developed some very early tools. We developed the first finite difference radiator evaluation tool, fluid flow evaluation tool, which you could use on radiators. We developed the first system evaluation tool, called a G-189. I shouldn't say we developed it; actually, again, we were a part of the development. We paid the bills. I guess it was Vought, Vought Aeronautics,

did the radiator. They were called Chance Vought in those days, I think. I think it was McDonnell again that did the G-189, but it was a good system tool that could evaluate a very sophisticated life support system. We were doing tools. We were doing technology. We were doing testing. We were doing studies.

WRIGHT: Were you making changes to your facilities, adding more?

GUY: Yes, actually, the Building 7 started out almost empty. We had the eight-foot chamber we got from the Navy, I think. I don't remember exactly where we got it from. We built the twenty-foot chamber as part of the facility. Then we added a leftover Lunar Module facility, which had a built-in Lunar Module life support system and also had a chamber you could use for EVA, and we did all our EVA testing there. Later I added the Shuttle environmental test article, I guess it was called. It's a very large cylinder inside which is basically a forward crew compartment. It's got a middeck, a half deck, forward deck; it's everything.

Then there was a large, pseudolarge, chamber that I had gotten off excess from Langley, where we did all of the Shuttle development testing. Later that was moved out into the adjacent—really, it was the old laydown yard. We put a roof on it and made a building out of it, but we grew plants. We grew lettuce in it for plant growth and tied that back into the life support testing.

We did put both a Shuttle airlock and a Station airlock in Building 72, both of which are still there. We can do all the EVA testing in the airlocks, decompress them. We did quite a bit of facility augmentation. In fact, the twenty-foot, it was put there originally. I put a sleeve in it so that we could raise the lid up another ten—ten feet? I don't know how many feet, eight feet,

so that we could make a bigger volume chamber out of it to put more hardware inside it. The twenty-foot is where we put the Apollo Command Module I told you we got. It went in there.

WRIGHT: Through all this time, too, you have a lot of supervisory roles. You were branch chief and you were in charge.

GUY: I was everything. You cannot be anything in a division that I haven't been.

WRIGHT: Can you tell us some of the changes or things that affected your job? Just being the supervisor of all the types of different elements and the aspects that you have explained to us, how it affected you as far as making sure everything got done the way that you felt it needed to be done. I guess in a short form, the evolution of supervisory—or maybe it wasn't evolution; it was just the changes of bureaucracy from the first times that you took on a supervisory role, and how those changed through the years.

GUY: I don't know that I can answer any of those questions directly, but I can talk around the subject a little bit. The thing that's always struck me is the—you used the word evolution—the evolution of what a supervisor is. I think you only really understand that, or at least understand it in depth, if you start at the bottom. Obviously, everybody has to start at the bottom, but everybody doesn't do every job up the ladder.

There's a lot of variety of jobs. I've always been in Engineering. I've never been in the Program Office. I've never in the institutional side of the organization or the computer side of the organization or the procurement side of the organization. I've never been in those places.

My supervisory skills are tuned to produce engineering products, and I started as an engineer. I had a mentor who taught me the first things I ever knew about doing engineering.

When I came to Houston, though, even though I was only—let's see. It was the end of—oh, I guess it was January or February of '62. I was only out of school a couple of years. Everybody was new. Everything was new. I don't guess they had a lot of choices, but they created groups or units; they called them units in those days. I don't know why, but that's what we called them. You could be a unit lead, and I was a unit lead. I was only several years old, but I had more experience than all the people that were hiring, because they were basically cleaning out the universities and everything, hiring lots of young people. I was two years more.

The first part of supervision is nothing to do with supervision but with work planning, so it was my job, basically, to plan out two or three people's worth of work. Then make sure that the work was defined in a way that the product was what was needed and then monitor the development of the product and then do a quality audit on the product when it was over. And then the unit leader, you still have to work; part of that job turned out to be my job. I had to do that as well as the other things.

After a while—it wasn't very long. I don't remember exactly how long; you can probably check the records—I got to be a section head. Section heads had units that worked for sections, and the units had people that worked for the units. The difference is that when you get to be a section head, in those days, anyway, you generally had aspects of your section that each unit performed some aspect of your section. You're now coordinating from one level higher, but you're still doing a lot of work planning. You're still doing a lot of product evolution activity. You're doing a lot of quality checks. You're worrying about whether you're going to meet

schedule and budget and is the product going to be ready in time and where are you going to get the resources to get the product done.

Then, of course, the next step is assistant branch chief, and branches have multiple sections. Of course, those have all gone away now, but that's the way we were at the time. Then you get to be branch chief, and then I was an assistant division chief, and then I was assistant division—well, I've skipped; I was an office chief one time. They made this office and moved it on staff, because—I don't remember exactly what was going on, but anyway, the division wanted to be more in control of the conceptual work that was going on, the analysis work that was going on. They moved me up on staff with my little team.

But anyway, branch chief, assistant division chief. Then I was a special assistant division chief, which meant I had a domain. It was called Test and Development domain. Then I was a deputy division chief and then a division chief. Basically at each of those levels you're still doing the same thing, is you're creating product or work from a group of people. It's just that you're planning at a higher level. You're reviewing at a higher level. You're managing at a higher level. But the responsibilities are basically all the same.

The trick is to continue to do work without stealing work from the people that are supposed to be doing the work. You have to have independent kind of work, not integral work. You don't want to be doing a job that if you don't do your job, then your section head or your group leaders can't get their job done. But, you need to keep your hands on things and the higher you go the less you're able to do that, but you need the practical experience. Anybody that says, "I'm a good delegator, so as soon as I can get to that position, that's what I'm going to do," it won't be long that they're a poor manager. You need to keep your hands in things, but not as an interference to the organization.

Then, again, the higher you move, the more you get involved in commitments. Where originally somebody else made the commitment and then you had to fulfill it, sooner or later you have to make the commitment. But the test there is can your organization fulfill the commitment, because after the commitment is made, you don't have choices then. Choices or pain; live with it. The flavor changes, but it's still a product-focused organization, service-focused, whatever. But, I mean, there's some engineering function that's being provided, and the people are the resource base to get that done.

Somewhere along the way you're given responsibility for contractors. You're given either the resources to go acquire them, or maybe in the beginning you're told which contractor to use. But as you move on up, you get your own contracts, or you design whether to use existing ones or get new ones.

But all of that growth is a balance of learning to be value-added. Value-added is a tough job for a manager. Too many managers turn out to be the source of work for the team. When you're the source of work for the team, you have abrogated your responsibility. You're supposed to getting work out of a team, not causing them to do work for you. You learn along the way how to do that and how to be value-added, how to impose standards, because that's what management does. Management is supposed to set the standards, make the commitments, and enable the people to get the work done. If you don't do that, you're not a very good manager.

I had one more very, very good experience, and that was after being a division chief in EC [mail code for Crew Systems Division], which was my division from '62 to 1990. In 1990 the Center decided it wanted an Automation and Robotics organization, and it turned out, for several reasons, I guess—you'd have to ask somebody else. Aaron Cohen, I think made the final

choice, and Henry [O.] Pohl was the Director Chief. He and Aaron made the choice, though. You'd have to ask them what they were thinking.

But the obvious reasons why I was a reasonable person to do the job is that my division, EC, was completely capable of moving forward with the leadership that had been developed there, and that was a good thing. The second reason was that I had recognized several years earlier that robotics was going to be an attribute that was going to be very beneficial to EVA. I had begun working on dexterous robotics to aid EVA, and the Center wanted to pursue that as a focus. They really weren't interested in Martian rovers and little whatever, stuff that JPL [Jet Propulsion Laboratory, Pasadena, California] and Ames and them would do. But they were interested in robotics to assist the crew and, of course, the vehicles. Shuttle was going to have a robotic arm, so it had to have a management home.

By 1990 the Shuttle arm already existed. It had been kicked around within several divisions, and it really didn't have a home, that was part of the native core work of the division was to take over the robotic arms. Of course, Station was talking about its robotics systems.

But the EVA was the focus, and I had set up a building, Building 34, which was a little robotics lab that I had set up when I was in EC, and I had some robotic experience. Also, Station needed—at least its specification said it needed—a little retriever vehicle that it could, if a tool was lost or a crewman was lost off-Station, you can't fly over and get them, because the Station won't move. You're lucky if you get a reboost out of it, that wasn't a good deal. They wanted a little retriever, and I had sponsored a directorate-wide development of a little retriever vehicle, and we had run some testing on it.

For those reasons and who knows what else, I was asked to head up this division, and it was from nothing. There was no division here. In fact, the building was used by others. They

said, "Well, (a), we're going to clean out the building, and (b), you need to put together a division." When it all ended up, I had only three people that I ever worked with before. I had a division full of strangers, and no supervisor that I ever worked with before, and my Admin was new, and my IT professional was new. My secretary was new. Everybody was new. Three engineers.

It was a very good experience to basically have a clean slate that says, you know, this can be what I want it to be. As I said, I already had ten years of being a division chief, and I'd already had whatever that—thirty years of being inside a division, and so I had a good idea as to what I wanted. It was a really good opportunity.

I don't know if that answered any of the questions you asked or not.

WRIGHT: It did. It did, and I'm looking forward to the next time that we talk so we can hear more about the retriever and the development of that nothing into something.

GUY: It turned out that they changed the spec. The specification that said they needed one, they decided they didn't need one. So we did the technology work, and we later on devised several other things, one of which was the SAFER [Simplified Aid for EVA Rescue], which is a crew rescue device, and then we developed a flying camera called AERCam [Miniature Autonomous Extravehicular Robotic Camera]. Then we followed that with the development of a Mini AERCam, which is a seven-inch sphere, little spacecraft that big around. We flew AERCam, and of course we are flying SAFER. We have not been able to fly Mini AERCam yet, but we will. We've developed Robonaut up there on the wall, and we've developed Tendril, Spider, Centaur, Scout, lots of things. Moving the front forward.

WRIGHT: Yes, and more to come, I'm sure.

GUY: If we get the support. NASA has screwed up its technology, though. It's very, very difficult to get technology support these days, very difficult.

[End of interview]