NASA JOHNSON SPACE CENTER ORAL HISTORY PROJECT
ORAL HISTORY 3 TRANSCRIPT

WALTER W. GUY
INTERVIEWED BY REBECCA WRIGHT
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WRIGHT: Today is January 29th, 2007. 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. This is the third oral history session with Mr. Guy. The first interviews focused on his experiences from his first days with NASA until the end of the Apollo-Soyuz Test Project. We begin today talking about the end of the 1970s.

We'd like to begin by asking you about the transition that your directorate started from the Apollo era to the Shuttle time period, if you could pick up from there and tell us how that all began and how you moved into preparing for the future.

GUY: I don't recall as much of a stir over the concept of transitioning between programs. There was a lot of parallelism early on. Mercury, Gemini, and Apollo were basically concurrent programs. Skylab was an outgrowth of Apollo using Gemini parts, using Apollo parts. The concept of multiple programs, the concept of supporting multiple programs, the concept of Engineering being involved in multiple programs, was just the way it was. Now we have transition teams and all sorts of other artifacts of the fact that [the] Constellation [Program] is coming online and the Shuttle is going offline. I don't recall any of that formality that I see now. It could be that I just wasn't at the place organizationally to see it or to be aware of it, but I don't recall it.

My view is that as Apollo was winding down, then Skylab was viewed as the precursor to a Space Station, and the general wisdom was that the next NASA program would be a Space Station. I'm the wrong one to try to understand the politics or whatever occurred at the upper levels that changed that thinking. I do know that [Maxime A.] Faget wanted a transportation vehicle, and therefore we worked on a transportation vehicle.

The early Shuttle activity was largely in-house, I believe. I don't know that any other Center was involved in any large extent in the design and development of the Shuttle Orbiter. Obviously, Marshall [Space Flight Center, Huntsville, Alabama] was involved in the launch system, but if other Centers were involved in terms of the concept of the Orbiter, the design of the Orbiter, I don't have any knowledge of that.

The vehicle as a pseudo-airplane was, of course, part of the quick turnaround. The Shuttle was supposed to fly, I think, fifty times a year, and it had a rather quick turnaround, and therefore you had to fly it back to where you were going to launch it from. That was impossible. You couldn't put it in the water because the refurbishment took too long. It was even questionable as to whether you could reuse it after it had been in the ocean.

My recollection is a Faget-driven Center initiative to design an Orbiter, and I'm sure it had a lot of early activities that involved vehicle-level considerations, but at some point the details of the subsystems began to be important. All of the different parts of the directorate were involved in providing their expertise to the development of the details of the design.

All of that culminated, at least in my memory, in an activity that was probably akin to what's now called a Skunk Works activity, but it was a dedicated in-house design activity that all the subsystems participated in, and as a result of the product of that we had basically a vehicle design, and that was the basis of the procurement, or at least that's the way I remember it.

That Skunk Works activity, again, I don't have a good feel for the time frame, but it was months long; plural, months. I don't really know exactly how long. I think it was held over in Building 36, I believe was the location. My job in what was then Crew Systems Division, I guess, was on the conceptual side, the advance side, the analysis side. My organization was always the organization that provided the support to whatever initiatives for new vehicles were needed. I personally participated in the Skunk Works activity. I was over in 36 for quite a while as part of that activity.

It's hard to keep all of the sequences exactly right; other sources would be better for guaranteeing the sequence, but my view is that that Skunk Works activity was the basis of the RFP [Request for Proposals], which was the basis of the procurement, and I was on the technical committee for evaluation of the proposals. Since we had basically specified what we wanted, the proposals were pretty much in line with the Orbiter that we had worked on in the conceptual design sense. There were some minor subsystem variations, but I think the main Orbiter was pretty much as had been designed.

I do remember between some of the proposals there was a difference in how the airlock was configured. I believe one of the proposals put the airlock in the nose, if I remember right. There were some configuration differences, and there were certainly some subsystem differences. We had wanted a regenerative system to collect CO_2, and the winner proposed to use chemicals, lithium hydroxide, the same thing we'd used in Apollo and Lunar Module and Gemini and Mercury. We weren't happy with that.

But the vehicle contractor was selected, you know, based on an overall winner and not on any particular subsystem. We worked with whatever they proposed, because in order to change

it, there would have had to have been a negotiation likely, which would have cost money, and at the time I'm sure the program manager had his financial troubles just like the ones today.

Some of the attributes, though, that we had come up with were in the proposal. We had changed to a flash evaporator from the old problematic water boilers that we had dealt with in Apollo, and that was in the system. The radiators were basically our design; we had already designed those and tested them. We knew what the configuration of the radiator system; the fluid selection was our fluid selection. The shared heat rejection capability between the flash evaporators and the radiators was accepted. Basically the thermal control system was pretty much patterned after our design. There were, as I said, details in the life support system that were different.

After the contract got under way, we took several of the lessons that we had learned and decided that we wouldn't relearn them. One was we wanted some systems engineering as part of the basic contract. We had largely done systems engineering, at least that's my view, in the Apollo era, but we wanted a contractor counterpart for that in the Shuttle. The thermal modeling, we wanted that done once and used by everybody, as opposed to everybody making their own models and arguing about the validity of the results. We were able to institute that.

In Crew Systems we had put together a breadboard life support system very early on and were able to influence the design as the system was developed. Also schematically we had a lot of influence over the way in which the system was designed. I do remember the Shuttle was an oxygen-nitrogen environment, and we had developed a very simple and elegant partial pressure of oxygen control system. It was really simple, and I remember we were glad that that was accepted without any kind of an issue, because it really was a good solution to the problem.

But as time went on we had to go to multipressure vehicles—or the cabins, not vehicles. The aft flight deck and middeck were open, that was the same part of the pressure volume, and as part of the EVA [Extravehicular Activity] scenarios we ended up with a nine psi [pounds per square inch] cabin to assist in prebreathe. Some of the reentry scenarios, I think, had an eight psi cabin, so there was some multipressure capability that the system had to have.

We did a lot of testing up front. As I mentioned, we had already done a lot of the radiator testing early on. When the design finally got put together, we retested a full-up system.

WRIGHT: Did you do those testings here?

GUY: Did them in Chamber A. Some of the smaller radiator tests we did in B, and then the large test we did in Chamber A. We had a full-up thermal control system, which was a very large integrated thermal test, in Chamber A. The early radiator testing we did was really fortunate, because some of the issues, particularly in the coating area—we wanted to go to a silver Teflon radiator coating, and we had adhesive trouble; it all fell off. But we learned that early, and it didn't really affect the program. I think that's the key to a successful program, is understanding your problems early enough so that they don't really dictate the program flow; that when you do a program design or a design that's part of the main program, that it has little issues associated with it.

The life support testing that we did early on then was supplanted with some additional testing we were able to do with the certification hardware. The way a program runs is the vendors basically build subsystems and do certification testing, and then that hardware is basically then junk hardware. We acquired all that hardware. It was still of the correct

configuration, and if you preserve it, then it can be basically put together as a hangar queen, so that it has the same attributes that the vehicle has. You can do a lot of operational testing with it, a lot of off-nominal testing, testing that the program can't usually afford or doesn't usually afford.

The contractor was Rockwell or North American or whatever they called themselves in those days. They had put together a large metal cylinder that they were going to outfit as the crew compartment, and the way they were going to do that is put the internal structure and then foam the contours so that all that was left was a volume that was equivalent to the volume of the cabin. Then they were going to do all the plumbing and the wiring in that vehicle, mockup, chamber, whatever you want to call it. It turned out that, for a reason I don't remember, they decided not to do that, but it was after they had already built the—it was a large can is what it was, very large can—and they had the secondary structure built.

We acquired the life support from the vendor, and we acquired the large can and all the secondary structure from Rockwell, and put together a chamber over in Building 7 which we could outfit as basically a cabin test article. It had everything in it. It had waste management. It had the life support system, all the thermal systems. It had cold plates, all the fans, the gaseous oxygen-nitrogen system. It basically was a full-up system, and all the operational testing that was needed, particularly to look at the pressure variations in the cabin, we did in Building 7. It was a very valuable test article.

We also recognized that since the contractor had no ability to do man-testing, that the airlock man-rating would have to either be done by analysis or we would have to do it. We convinced Aaron Cohen to have the government do the airlock man-rating, so that airlock was

shipped to Houston, and we attached it to this large can. We called it the environmental test article, ETA.

It was connected, and then the other side of the airlock was connected to our vacuum systems through their eleven-foot chamber. We basically could run a full-up airlock testing, which would start out, of course, at sea level and then would depress down to vacuum. We had it so you could open the hatch and use the support systems in the airlock to keep the crew alive. It was a very valuable test capability, and in fact it's still used today. All the EVA crew go through the airlock test article, as part of their training.

When Station came along, we already knew that was the right thing to do. We convinced Station that we should do the man-rating of the Station airlock, too, and it's now available and is used by the Station crew as part of their training. But the basic certification testing was done here on-site.

Shuttle was a very satisfying program from an engineer's standpoint. We had done the precursor work, both testing and design, and the procurements basically bought what the government wanted to buy, and the contractor was experienced and could build the vehicle, in my area, appropriately. I guess if you talk to people on tiles and stuff, they had a lot of issues. I remember the tiles fell off as they transported the vehicle to the Cape [Canaveral, Florida], and they had to put them back on. I'm sure there were a lot of other areas. But in our area we had influence, and our participation was accepted as value added. Basically Shuttle was, I think, a good development cycle for the engineers that worked on it.

I mentioned in earlier discussions on the Apollo that we had some open conflict on several of the areas, where we had to go to the program manager and get the contractor stopped and redirected. But my memory on Shuttle was that if that happened, it was rare. I can't even

recall an incident that we took issue with that we were not able to resolve without a big showdown.

WRIGHT: When the Approach and Landing Tests were about to begin, and even when they were over, were there a lot of engineers there to help determine what the results [were], and how did you process the information after those tests were concluded?

GUY: There was very little significance to the early testing. The [OV-101, *Enterprise*,] is what you're talking about?

WRIGHT: Yes.

GUY: Our system really was not significant in that testing. Until you actually got on orbit, you couldn't really tell when our systems were doing their job or not.

WRIGHT: What did you learn after STS-1?

GUY: We learned a lot of things after STS-1. I think the main thing was that all the basic designs were good designs. I've forgotten whether it happened on STS-1 or not, but the flash evaporator, which was a much better design than the water boilers used to be, Rockwell had picked a vendor different than the vendor we developed the concept with. Basically, the vendor had to relearn everything. They did go with the right design, but they didn't have the experience that the vendor that we'd developed the flash evaporator with; they made lots of mistakes.

One of the mistakes was a very complicated control system with inadequate instrumentation. They got into freeze-up situations fairly frequently. Again, I don't remember whether it was STS-1, but it certainly could have been. We ended up with freeze-ups.

We had tested the flash evaporator, both the original one, which worked well, and the one Rockwell had built, which, at least from a control systems standpoint, was somewhat problematic. We knew it was going to potentially freeze up, and we knew how to recover it; we could always operationally get around it. We never really had any kind of vehicle aborts or anything associated with it. But we would make icicles pretty regularly and freeze up the steam ducts pretty regularly. But again, we knew how to solve the problem, so we did.

We partnered with MOD [Mission Operations Directorate] and educated them on what we had learned, and when the circumstances would occur, they knew what to do. And we were always in the MER [Mission Evaluation Room] to help, sometimes we could predict it before it happened and avoid it, and sometimes we'd get rid of it after it happened. That might have been something that happened on STS-1. I don't remember.

But the radiators worked really well. We never had any issue at all with the radiators. They were a completely different kind of radiator than we'd had before. The Apollo radiator was a radiator that basically used the fluid properties to adjust its size, but the Shuttle radiator was always just very large. There were eight panels, four of which were two-sided; lots of tubes per panel, twenty, maybe twenty—I don't know—lots of tubes per panel. Each door had four panels, two of them two-sided, and each was a separate system. It had a lot of redundancy and a lot of heat rejection capability. But it worked, and it really never gave any kind of a problem.

We had gone to a Freon coolant, which basically allowed us to not concern ourselves with the changes in viscosity based on the temperature. Those are the parameters we used in the

Apollo radiator, but with all the parallel paths in the fluid system, you don't want viscosity changes. You want to be able to ignore them, and the Freon did that rather well.

As far as the cabin, I guess the most problematic system was the waste management; that was another system that we had done some work with a vendor to try to solve some problems, and Rockwell went with a different vendor, and we ended up with fairly long-term issues. It took us a long time to get—I don't remember how long, probably more than several—I have no real idea, but it was not within the first ten flights. We had waste management issues a long time before we finally got an operable, functional system.

In fact, we actually put together a Tiger Team, which I led. [William E.] Thornton was on it. Judy [Judith A.] Resnik was on it, and several good engineers. We figured out how to make acceptable what we had. It was not in the cards to redesign it. We had to find ways to make the current design, with fairly reasonable modifications, work, and we were able to do that. But I still don't think the waste management system in Shuttle today is anything to brag about. I think it's adequate, but it's really not as good a design as it probably could have been.

But that's really an issue that I think every program has, is they have to pick the contractor that basically has the best overall plan and understanding, but at the subsystem level there can be vendors and designs that are just not as good as we could do. But the alternate to that is you pick all the vendors for your contractor, and if you end up doing that, then you become responsible for whatever happens, and no program manager wants the contractor to not be responsible for his product. That's the posture you have to be in if you want the prime [contractor] responsible for everything; you have to let them do their own thing.

Sometimes, though, it can result in a big programmatic change. When Station first—well, the proposal and the winner and for several years, we worked on a two-phase thermal

control system, which, in fact, was the right answer. But again they didn't pick the right vendor, right meaning the one that we had worked with and had a lot of experience with. After a couple of years they basically abandoned it, which was to the detriment of Station. It would be a better Station if it had a two-phase thermal control system. But sometimes that happens.

WRIGHT: Speaking of Station, you worked as a chair of a group for the Space Station Technology Steering Committee for NASA Headquarters [Washington, D.C.]. Was that a subject that came up then, or what were some of your primary discussions?

GUY: That came up in the early eighties, because the thought was that if Shuttle was coming on line, and that the agency should now turn toward the Station, which was supposed to be part of a natural evolution into space. But Congress was really very resistive to NASA even talking about Space Station, and they made up some rules that I never really understood, but they actually controlled how much money you could spend on looking at the next program. It was some catch-22 where if they hadn't authorized a new start, you couldn't spend any money on it, which was absurd, because you should spend money so that whatever new start they authorized was an intelligent approach. Regardless, I've forgotten the number; it seems like it might have been as small as ten million, maybe even less than that; that's all you could spend.

The agency couldn't spend any money on Station, and so we did a lot of in-house work. In those days we didn't have restrictions on how the civil servants were used, so we did a lot of in-house work. But our view, the engineering view of what the Space Station should be, we called it a Space Operations Center, a SOC. We did a lot of work on the SOC. My area was still the radiators and advanced life support, regenerative life support. I supported those areas, and

the suits, the airlocks, EVA equipment, and that kind of stuff. We had a new Space Station suit proposed. We had regenerative life support proposed. We had the two-phase thermal control system proposed.

It turned out the Space Operations Center had the idea that you would do a lot of things in space. You wouldn't just put up a lab module or something; that you would repair satellites. That you would assemble vehicles to go to other planets; that you would have a co-orbiting laboratory that you could put unmanned experiments on so the gravity would be extremely low-gravity situation. It was more of a full-featured Station.

But [NASA Administrator James M.] Beggs could only sell an $8 billion Station, and you couldn't buy that for $8 billion. In fact, you probably couldn't buy what he sold for $8 billion, either. But I think if left alone, we had a shot at that, but we weren't left alone. We had all the political meddling that happened where we had to spread the work out all over the country and create work packages. Then there was capped funding. You couldn't spend but so much per year, which stretched things way out. Then the configuration of the Station changed. Well, there was a lot of issues that I think were politically motivated that prevented any kind of expeditious building of a Space Station. But from our perspective it started out right.

You mentioned the technology programs. About the last two years before the program actually kicked off, it was Code R in those days. R was the technology arm of the agency. Code R had a two-year initiative. The first year I believe they carved out fifty million, which was a fair amount of money in those days. They had these technology panels, and I was responsible for the agency's life support initiative, and my deputy, Will [Wilbert E.] Ellis, was responsible for the thermal, agency thermal initiative. We had members from all the Centers that were

involved, and even the life support and the thermal, and we developed plans and vied for our part of the fifty million to get those plans done so that the technology could be firmed up.

The way we did it with the thermal control is we developed some concepts, put together some ground testbeds, and actually flew some experiments on the two-phase thermal control system and some heat pipe work that we were doing.

In the life support it was our goal to put together an integrated regenerative life support system, and over in Crew Systems we had a twenty-foot-diameter chamber that I was able to get a C of F project for and put an extender in it so that it made it a two-floor chamber. We were getting regenerative life support systems for proof that you could support a crew, because we were doing lockup testing in those days. We put the crew inside the chamber and did thirty-, sixty-, ninety-day tests with the crew inside the chamber. That was our approach.

Both those were good approaches. They would have solidified the technology. But as the political situation interfered with implementation, the regenerative life support was very marginalized, and the two-phase, as I said, went away. The preparation we had done was not capitalized on by the program.

But at least for those couple of years we did some really good technology work to close down the gaps so the program could count on those technologies. In fact, we were so successful that when the RFP went out, those were the technologies that were in the RFP. I was the Technical Chairman for the evaluation of the Space Station proposals, and that's what was proposed, so we were in good shape. When the contract was let, we were in good shape. It was just subsequent to that everything sort of slowly fell apart with all the political harangue that was going on.

The first thing they did was reduce the responsibility of this Center with putting the life support at Marshall under their work package, and they really had not been a player in life support. Ames [Research Center, Moffett Field, California] had been a player in the life support area, but Marshall really hadn't. They didn't have any background at all. It was sort of the problem that I mentioned earlier. When you pick a vendor that has no experience on a subsystem, then they can't move forward. They have to relearn things.

The first thing Marshall did is they went back to all the vendors that we had dealt with and bought a version of the hardware that we were buying. It was called the "blue-light special." Kmart used to have the little blue light for the sales. The contractors were scrambling, because they had built credibility up with us, and now this new Center [had] no experience with them. I think they really did get some really good deals on building some of the hardware that we had built or built the second version and took it down and took Marshall for some testing.

I tried to convince the Work Package Manager, who was Luther Palmer in those days, to try to use the capability that we had built up here to move forward as opposed to start over again, but I was unsuccessful at that. They basically started over. They also had some biases back toward Skylab-vintage systems, so they retreated, as far as the design evolution was concerned.

That was not a very happy time, because we had carried the agency along in life support since the sixties and sort of building for the Space Station; all the life support systems in the other vehicles are pretty trivial. It doesn't take a lot to keep somebody alive for ten days or something, two weeks. For years, it's a different technology, and we've been working on it and maturing it, and as I said, it was in the contract. But it just didn't happen. From my perspective, anyway, that was a mistake the agency could have avoided but didn't avoid.

WRIGHT: In the early to mid-1980s you were promoted to deputy chief and then took the role of chief in the Crew Systems Division, which was later renamed Crew and Thermal Systems [Division]. Tell us about your expectations of taking on this new—not new division, but a division you had been a part of that had about ninety people, a hundred people or so. Did you take it on a different course, or what were your expectations for yourself in taking on the lead role?

GUY: Two or three things you said there that I would probably challenge. I think we were probably over a hundred people at that point. I don't really have a count at all, but my feeling is that we—subsequently there was some shrinkage, and I think a hundred is about as low as it ever got. I think it was larger at that point.

It was really a multifaceted division, and a lot of the domain of the division we had put in place with good, sound engineering over a lot of years. When the division first started, it was called Life Systems Division. It had all the medical people and all the habitability people. It was led by a doctor; Stan [Stanley C.] White was an M.D. It had a lot of the flavor of spacesuits, pressure suits, electric shavers, toothpaste, underwear; sort of the medical side. That was certainly not my area.

My area was what was called environmental control in those days. In fact, there was a dispute within Faget's [Engineering] Directorate as to whether we could—we in Crew Systems, or Life Systems in those days—what role we should have in environmental control, maybe a minimized role or some sort of a truncated role. But we had a very competent staff, and we had the test facilities. Over time the environmental control side grew, and that's where the thermal

came from is that the thermal control system really turned out to be an external heat rejection system that was completely different from the old environmental control.

The concept of environmental control means, you know, that's your air-conditioning. Well, obviously, vehicles had begun to have radiators and flash evaporators and other methods; that was a lot more than just the air conditioner. As time went on we developed expertise in the radiators, thermal controls, and in regenerative life support, which again gets more into processes. You have to process your wastewater to get your good water. You have to reclaim your oxygen from the CO_2. It was a much more full-featured.

By 1980, which is when I took over, we were well-established, full featured, no charter issues, no issues, and much more balanced. By then the doctors had been moved out. We still did a lot of the stuff called crew equipment which is the cabin-type stuff, whether it's razors, or toothpaste, or underwear, or clothes, or whatever. We still did that, but it didn't have the organizational dominance that it had earlier. We had gotten into EVA and EVA tools so very strongly, and we were doing as I said life support. We were leading the agency in regenerative life support and thermal control, both. It was much more of a full-featured decision.

The EVA world, where my natural early career was in the life support and thermal area, the spacesuits had also become full-featured, as opposed to just a pressure suit like an aircraft has or like Gemini had or Mercury had. You began to have something they called an EMU, Extravehicular Mobility Unit, and that has a life support system with it and a thermal control system with it.

You could know everything about pressure suits and you weren't there; you could not build an EMU. In fact, that's the way the vendors were. There was ILC [International Latex Corporation], who built the early suits. There was David Clark, who built pressure suits. But

when you began to have to have a life support, then you had to get a different vendor to build the life support, because the people that did soft goods, the cloth and the whatever, the rubber, molded rubber and all, they really weren't the right people to do the life support.

That basically diversified the area that I was working in into the life support and thermal control for the EMU, and my first branch job was assistant engineering chief, branch chief, and that job basically was to integrate the two pieces, the suit side and the backpack side. That was the basic focus of that job. We also did the integrated life support and thermal, too, but we had always done it, so it was getting done by itself.

But at the time that I took over the division we were at the point of beginning the certification program on the Shuttle EMU, and within several months of my taking over we had a fire with the suit hardware, which was a big setback. Basically the early pressure for the division was to recover from the fire and still make the first flight. We had to be on the first flight. We were able to do that, so that part worked out all right.

But we had the subsystem manager work for the thermal control and life support system on the Shuttle, and then we had the development contract. We actually had the contract; the GFE [Government-Furnished Equipment] contract is what it was called, but it was our contract. We managed the contract, and we managed the contractor to develop the hardware and certify the hardware. Again, since man-testing was only done here, we did all the certification here on-site in the chambers in Building 7 and in Chamber B. We used Chamber B to do the certification, just like we had done for the Apollo hardware.

To get back to your question, I had always supported the advanced mission initiatives from whatever position I was in within the division, but it never really was much of a division emphasis, and I guess the only change that I would say occurred was the divisional recognition

of preparing for the future, trying to make sure that Station had the right systems and subsystems available to it at the time that it was put in place. As I said, we did our job, but it didn't work out.

But still I'm a believer that there are things that are not in your control, and you can't judge your own success by things that you don't control. I think we served the agency by having those available, and circumstances prevented them being used, but so be it. I don't think that would have excused us for not having them available, so we did.

But I guess that would be the only change, and I don't know that it was much a change. They always allowed me to sponsor division activities; every division chief I ever had. In fact, the last two division chiefs were really completely different people. The last division chief was Jim [James V.] Correale, and he came from the pressure suit days and I think it was the Naval Research Lab [Washington, D.C.]. He was very EMU suit oriented.

The one before him was Robert [E.]—Bob Smylie. He went by "Ed;" we called him Ed Smylie. He was from the aircraft industry and was very vehicle-focused. Of course, the period of time was the Apollo-Soyuz time, not really the Space Station time. But he was very vehicle-focused.

By 1980, which was after Smylie and after Correale, we were really right in the midst of getting ready for the Space Station. There was a lot of vehicle-level activity going on at that period, and we certainly supported that activity.

The only other emphasis, and it really wasn't a change, because the previous division chiefs recognized that we should always have a forward-looking element. It's not a change. But I certainly believe that, and I made sure that, as long as I was in the lead, that we never let the current program's priorities eliminate our advanced activities. We always had technology

activities going on. Sometimes they weren't sponsored very well, they weren't very large, but we never got to the point where we abandoned the forward-looking aspect. I still believe that's true; that's what I do in the division I have now is that we always have a forward-looking aspect.

WRIGHT: How did the *Challenger* accident, and then, of course, the time period afterwards until there was return to flight, affect your projects?

GUY: The stand-down of course was bad for everybody. Anytime you go into a mode where you're not moving forward, I think it's bad for the whole organization. The problem the *Challenger* was halted for, was basically not an Orbiter problem and certainly not a problem that had anything to do with our subsystems. We were basically observing the political situation. We did all of the review things that everyone else did, reevaluate the designs, reevaluate all the failures and whatever. But there was nothing really that came out of that that was significant to our subsystems. We just coasted, treaded water, whatever the right word is, until we could get back flying again.

Where it's a tragedy [is] when human life is lost. There's nothing casual about that. But it was almost as if there had been no recognition, that everyone had sort of forgotten the Apollo fire, and there had been no recognition that this was a percentage chance that it could happen to you. And where that particular problem with the seal is something that probably should have never caused the problem—it should have been caught and fixed—the circumstance of actually losing people was so dramatic, so important nationwide, that there was a tremendous amount of caution associated with flying again. There were probably some solutions that could have had us flying earlier, but they just were not politically acceptable.

In fact, almost immediately after the incident there was some work done, which we participated in, which was an unmanned Orbiter so you could launch without people. You could, if you were willing to take the risk that you'd fixed the problem, then you were only risking hardware. You weren't risking any people. That's actually completely doable, but it was viewed as probably politically unacceptable. It never went anywhere. But I think an unmanned Orbiter was completely viable if somebody had wanted to do it.

WRIGHT: Maybe that would be a good lead-in to what I wanted to do for the next topic, which was Aaron Cohen's decision to form the Automation Robotics Division. Tell us how you got involved in that. Our research shows you were very instrumental in meeting with a lot of people on the Center to start building that division at an early time period.

GUY: You've talked to Aaron and probably Henry [O.] Pohl both, and they probably have much better insight as to exactly what the thinking was at the point of creating the division. I was in Crew and Thermal Systems and happy. In my view I had the best division and the best infrastructure of any of the divisions. We were set to continue into the future.

But as part of the activity, about three years earlier—this is in 1990 that it was formed, somewhere around '87 or so it seemed to me that robotics could be used to augment the EVA activity. I began working on some dexterous robotic devices, hands. Various researchers were developing hands. There was a Utah-MIT [Massachusetts Institute of Technology, Cambridge, Massachusetts] hand. There was a Barrett hand. There were several hands around. I bought some of each, and we began doing testing for augmenting an EVA crewman. We looked at potentially even adding a robotic hand to the suit.

One of the really big problems with pressure suits is that the glove is a big encumbrance, and it's also fatiguing to use. You know the little ball they give you for your heart? It's like squeezing that all the time; it doesn't take long before your fingers get tired. It's a big problem; we were looking at that. We had worked on several robotic devices. Actually, it was a power station building adjacent to my building, and I talked them into giving me about half of it. We fenced off the power part and created a laboratory to work on robotics, so we worked on robotics. I had a robotics activity already under way.

I was not really worrying about the arms in those days, the big manipulators. In fact, I'm not even sure—that was pretty much Program Office. There really wasn't much engineering work on the robotic arm. There had to be some, obviously, but I don't think there was very much.

The other initiative was a congressional initiative that said robotics is important, and one of their earmarks was robotics. They required some robotics activity to occur, and they needed a report every year that said that some robotics activity was occurring. That may have been part of the trigger; I don't really know. You'd have to talk to either Aaron or Henry. But they did decide that we should recognize that both the robotics and the automation, or intelligent systems or whatever other word you like, were going to be important to the future of the agency and the Center, and that creating a division that had that as a focus would be a good thing.

They reorganized, and there was an Intelligent Systems Branch in one of the divisions, the Avionics Divisions. I don't even think there was an actual branch named Robotics, but there was some robotics work going on around, and of course, I had a little robotics work going on. They decided to put all that together and make a division out of it.

It turned out that the original complement that they came up with didn't include everything, so it was only a partial assimilation of the directorate's activity. The first charter was for me to go gather up the other pieces and get them colocated within the division. That was a pretty unpopular activity, but anyway, it was necessary.

I did that. I went and negotiated with all the division chiefs and got the pieces of the robotics activity that were going on around. Structures had a little bit; ES [mail code for the division]; some of the Avionics people had some. And as time went on some of the other robotic activities, for example, the Life Sciences Directorate, SA [mail code for the directorate], had a robotics trainer that I took over, and then the new robotics trainer for Station they were developing, and it got in trouble financially and programmatically, and the Engineering Directorate picked it up, so I ended up with it.

Over time just the various pieces came together, I don't remember exactly how long it took, but probably within the first four to six months, we got all together, and they gave me this building. We set up here and have been here ever since.

WRIGHT: Tell us about some of the projects. When we ended our last session, you had named a few. And, how you began a partnership, for instance, with DARPA [Defense Advanced Research Projects Agency]. How did that come about?

GUY: Well, as far as the projects are concerned, being a person in an organization that's responsible for technology with no funding is not a good place to be. We began to participate in the agency's forums. At that point there was a robotics forum called Center Robotics something

or other, and I've forgotten exactly what it was called. But anyway, there was a forum, and we went to the forum.

You can't be effective, because it's a zero-sum game, so basically if we got any money, somebody else had to lose it. It's not very effective, going in with a bunch of promises of how you're going to do better than they're doing with their money. We said, "The first move is to create a competence base that we can sell what we do as something that the agency needs and that we can do it better than anybody else." We developed a set of in-house projects. We called them target projects. In those days there was sufficient support internally that we could do that, and we had a little bit of money and some civil servants.

We began to work on an area that nobody else was working, because that's the second strategy, obviously. Taking money away is one thing, but taking responsibility away is another thing. We didn't want to mess with anybody's responsibility. We wanted a new domain.

We began to perpetuate the domain that I had started in EC [Crew and Thermal Systems Division mail code], which was basically human-robotic interaction and augmentation. It turned out at the time we were the only people interested in that, so we could establish ourselves fairly soon as a competent source for activity in that area. We competed in the forums and began to get a little money, and as time went on we got more of the money, and by the end we got most of the money.

We've pursued projects always in the vein of either supporting the intelligence side, which we've done with various different kinds of robotic testbeds: robots that can plan paths from point A to point B, robots that can avoid collision with obstacles, that can evaluate their health and go to alternate modes if they aren't healthy. We've worked on those kinds of issues, and we've worked on devices.

The first robotic device that had two arms and two hands and a head and eyes was a robot called DART, Dexterous Anthropomorphic Robotic Testbed, DART. In fact, DART is now moving to Space Center Houston [Houston, Texas] as a display. It's historical now.

Then as time went on we developed Robonaut, which is much more anthropomorphic and much more capable than DART was. We developed spider robots for climbing on a very, very lightweight structure. The reason for the spider, of course, is that it has eight legs and therefore it does not put very much load on any touch point. It can move very slowly and without disturbing the surface that it's on, just like a spider does. A spider is able to walk on a spider web only because it can spread its weight around.

We've worked on robotic cameras, Mini AERCam [Miniature Autonomous Extravehicular Robotic Camera]. We flew Sprint, which was an AERCam, flying camera. We've worked on a Tendril, which is like a snake robot that has a camera that it can go into small areas and do inspections.

Currently we have a Centaur version of Robonaut. Robonaut rides on the front of a mobile platform that can take it on the surface. We also have a Robonaut configuration with a one-legged stanchion on the base of it; it's called a Stinger. Robonaut can climb around on Space Station.

We've basically developed a line of robotic devices that are geared to support human activity as an assistant or even as a surrogate, in some cases.

Let's see. You asked about DARPA. DARPA was survival at a point where the agency decided that technology was not as important as I thought it was. [Daniel S.] Goldin abolished his technology organization, so it became very problematic to get any kind of technology support, and we were able to work with DARPA and find congruent goals, things they wanted

and things we wanted, and they sponsored us for several years. Sometimes when you can't get agency funding, you have to find some other way to get the job done.

WRIGHT: Did you have other means [than] DARPA? Did you have other agencies that wanted to—?

GUY: No, DARPA is really the only people we've been able to get, the only government agency. We're working now with General Motors to get some support in the robotics area right now. Again, what they need in terms of capability and what we need in terms of capability are congruent again. We'll have to wait and see how that works out. But there are times when the agency gets in a position where it needs all of its money to do something it wants to do, and the technology suffers when that happens.

WRIGHT: How does the vision for your division integrate into the future for Constellation?

GUY: Well, if they get past the current vehicle. The current vehicle is basically a crew transport vehicle. It takes the crew from the ground to Station, or hopefully, the Block II version of it will take people to the Moon. But it's basically a Command Module type of a vehicle. When they start the surface operation, that's where our technology is going to be critical. They are talking about building on the surface of the Moon a multimodule habitat, and they're never going to have an army of people. They're going to have to depend on some people and some robotic devices to make that work.

Also, the exploration, I doubt that all exploration will be done with the crew doing everything, that a lot of the geological activities could be done in partnership with a robot that has similar capabilities to a human to have a maintenance partner. Or, when the crew is not there, to have something that can do the maintenance between missions.

You asked me about robotic projects. We've been working the last two or three years on a surface rover for humans; it's called Scout. It's basically a rover like the Lunar Rover, except this time it's smart. This time if you get off and walk around doing exploring, it will follow you. If you know where you want to go, you can tell it, and it will take you there. You don't have to drive. It can avoid the rocks, boulders, and run over anything. It will accept voice command. It will accept hand signals. We've proven that with our field tests. In fact, we just came back from a desert field test last part of last year.

The partnership between the robotics and the astronauts, whether it's a rover, whether it's an assistant, or whether it's even a set of eyeballs that go do inspections that you don't want to have to waste your time doing prebreathes and putting on spacesuits and going out if all you're going to do is look. It's better to have that done some simpler way. For surface operations, we think we're going to be enabling. If we're not there, they're going to have to significantly limit what they can do.

WRIGHT: Are you doing a lot of interfacing and interaction with other Centers?

GUY: Yes. In fact, we're leading a new Surface Mobility Project right now that has, I think, two universities and three other Centers.

WRIGHT: That sounds exciting. One of the things that you had mentioned earlier, if I can ask you to elaborate on, is that as a preparer for Constellation you're doing transition teams and other types of concepts that weren't used earlier in your career when multiprograms were going on. Could you share with us some of the other differences, and one of the other ones I was going to ask you, too, is about how is the relationship between NASA and the contractors changed throughout the years as you've been with the agency?

GUY: My personal knowledge of that is really an artifact of the reconstitution of the Space Station at the point that Goldin changed it over to the International Space Station, so I don't know that I can answer that question really very well. The relationship that we always had with the contractors—we being the Engineering Directorate—was the smart buyer relationship, where we were the customer's representative, the customer being the Program Office. We were participants in all that went on. Engineering-wise, we were smart. Our opinions were valuable to the process. When the contractor, for whatever reason, either a technical disagreement or some contractual benefit reason, did things that we didn't think were appropriate, we, of course, appealed to the program manager. In most cases, when I was doing that role directly, we were listened to and the contractor was changed, redirected.

As time went along, then, of course, I was not directly involved with the contractor, but through the Shuttle we had that same relationship, because all the subsystem managers that worked for me dealt with the contractor and I was aware of what they did. In the very early Shuttle I was integrated in dealing with the contractor, but only in the very early days, and then basically I was too high in the management chain to be daily involved. But I had all my subsystem managers, and I think they had the same role. They had the respect. As I mentioned

to you, we didn't have the open warfare that we'd had earlier, but I think it was because there was a good relationship there.

When Station came along, it started out as if the same kind of relationship would exist, but when Goldin revamped the Station, he viewed civil servants as being a hindrance to the process. He put Boeing in as the owner of Space Station and all the work packages, contract work then for Boeing, and he fenced off the civil servants. We were not allowed to support anymore. There was actually a number. I've forgotten what the number was, but there could only be 200 or 100 or something, some number that you couldn't have more civil servants supporting the program. The theory was that the contractor will do it all right, and if you let the civil service meddle, they'll make the product more expensive and make bad choices. They'll try to make everything Cadillac and won't do it the right way. All that's a farce, but that was the stated agency position, and we were fenced out.

After a couple of years of being integral with the project, then they fenced us out, and we never went to the vendors anymore. We never went to the contractor anymore. We were out of the game. As time went on the project management began to see that Boeing was not the answer to everything; you had to believe what Boeing said because there was no way to disagree with it. You didn't have any technical people that were involved—and not just Boeing, but all the subcontracts. On a selective basis they began to use Engineering again, and that has evolved over time. By now we're pretty much back where we were years ago.

The problem is we missed the development cycle, and we're not as smart as we used to be. We used to know everything about everything. In fact, we had better continuity than the contractor. The contractor would lose people or move people to other projects and whatever

else, and we had lots of continuity. We don't really have that for Station. But I don't know that it had anything to do with the contractor didn't want us there as much as we just weren't there.

When CEV [Crew Exploration Vehicle] started, [Rear] Admiral [Craig E.] Steidle likes that model, the Goldin model, so he basically fenced us off again. When [Michael D.] Griffin came in, he said, "That's dumb. We're not doing that." We're now back participating, so we shall see.

WRIGHT: A couple of times, and not that long ago, you worked on or received awards for a couple of patents. Can you share with us how that process worked?

GUY: Actually, that's not really of any consequence. The patents had to do with trying to make the spacesuit glove a little more adaptable to dexterous activities, and we worked on some different surface coatings for the fingers and all. But I was a very minor part of that. That was done by other people that were much more integral with the process. I guess the reason I ended up on that is that I was pushing having something done better than what we had, and of course, they brought all the candidates, and I was part of the selection process in making sure we pursued what we needed to pursue. But I really didn't have the same technical role as some of the other people on the patent.

WRIGHT: I'm just curious. In the early nineties NASA became involved with the Russians again as part of the Shuttle-Mir Program. Did you have an opportunity at all to participate in that?

GUY: No, that was completely different. They let us fly some people on their vehicle kind of thing. They always have been and still are very secretive about what their system is and how they use it. In fact, even today we have issues. When they have a problem on their side, it usually takes us a day or so before they'll tell us enough about it so that we can understand it. That's just their culture is that it's theirs and they'll tell us what they want us to know kind of a thing. But no, there was really never any more—in the Mir—there was never any more participation allowed at the subsystem level.

The work we did, though—at that point I was already in this division, and there was a third element added to the charter of this organization. We always had intelligent systems or automation and the robotics, but the simulation area was added, and we did a lot of simulation work with MOD and the crew for the Mir utilization and we did some analysis, engineering analysis. But that was really the only thing we did is in the simulation arena. They wanted some specific things done, and we helped them get them done.

WRIGHT: Well, as I'm kind of closing down on the topics that I had wanted to talk to you about, the one that I'd like to ask you before we start to finish today would be that you've spent forty-eight years with the agency, and during all that time what do you consider to be the most significant accomplishment that you've been able to do while you've been here?

GUY: [Laughs] I don't know.

WRIGHT: Is there a more challenging time than others?

GUY: I think there's some subtle accomplishments that I feel very good about. I think that when I first joined the Life Systems Division, there was, as I said, more of a bent toward the medical, the habitability, the pressure suit side, and I think the evolution of that organization into a much more full-featured organization that was much stronger engineering-focused was in large part because that's the way the programs developed.

But I think the attribute that maybe I had something more to do with than just the program evolution was a dependence on studies and analysis as being the basis of designs and of design evaluations and of testing. My part of that organization was analysis. That's where I started, conceptual design and analysis. That was the first job I had with that organization, and as I mentioned earlier, the Lunar Module was the new thing on the horizon. We did all of the design and trade studies for the thermal control and the life support system and how to use a spacesuit inside the Lunar Module.

But because of that, analysis was just coming on as an important attribute of thinking about how good a design was or what the design should be; computers were in their early, early stages. FORTRAN was a brand-new language. In fact, my first computer course was in machine language. FORTRAN was just coming on the scene. The concept of being able to analyze life support systems and processes and radiators and thermal control systems, that activity was not really widely recognized.

I told you we had a lot of problems with the water boiler. We did all the analysis on the water boiler that said it wasn't going to work, and people weren't doing that kind of analysis. We did the analysis on the Block I Apollo radiator and said, "It's not going to work." Rockwell was using a steady state computer program that said it would work, and we used a transient program that said it won't work. It was just a higher level of bringing analysis into the game.

We did both the Command and Service Module thermal models. We did the lunar thermal model. We led that activity. It involved people all over the Center, but we led that activity, because we had an appreciation for analysis and how it could be used in system design and system evaluation. I think that that was a little early for its time at that point in time, and I think we were a much stronger division because of that.

Really the only big analysis tool out there was NASTRAN [NASA Structural Analysis System], and basically it was a structural tool; that's all it did. But if you had anything more sophisticated than a piece of structure, that had fluid flow and all of the rest of the issues associated with processes and all, well, the agency really wasn't doing much of that, and I think that's important.

I've always had a fondness, I guess, for that area, and when we started here in 1990 with robotics, the first thing we did was begin an analytical capability to be able to analyze and design robotic devices, and we have now something called a trick architecture. It's a simulation architecture that's used—actually, it's used all over the Center now. We've developed simulations for MOD, for all the training facilities, for all the engineering facilities. We are doing a lot of leading-edge simulation work right now.

I think that all of that would have happened anyway, but I think we were probably a half step quicker because we recognized the value of it and pushed it and did it ourselves. I guess that's one thing that I'm proud of.

Another thing I think doesn't always pay off, but somehow still doesn't change my pride. I think we've been forward thinking in all the jobs that I've had, so that we prepared for what the agency's next step was. I mentioned the life support that didn't pay off, but we prepared. The thermal control, we prepared three times for that. We did the Apollo when it was a failure. We

did Shuttle, and it was a success because of our design work. Station would have had a much better thermal control system had they used the technology that we did.

I mentioned inspection devices. As you now know, we're using a boom carrying a sensor package. That could have been done with a free-flying spacecraft if they had made that choice. They didn't make that choice, but we were ready. The agency could have made that choice. Robonaut right now is poised so that it can be an EVA helper. Whether they do it or not, I don't know, but we're prepared. The rover work, we're ready for planetary surface rover activity.

The Space Station used the Shuttle EMU, but it didn't have to. We were prepared for a next-generation EMU, which again they didn't implement. Another one, Skylab used lithium hydroxide to collect CO_2 because that's what Gemini did and that's what they used. But we developed a regenerative system, sold it to the program manager, and used it on Skylab. It's the molecular sieve.

A lot of times along the way we were essentially prepared. Sometimes it worked; sometimes it didn't. But I feel that the agency had a choice, and it's something I'm proud of.

WRIGHT: Okay. I'm going to get you to stop right there for just a second. I just thought we'd take a few more minutes of your time and see if there was anything else that you would like to add, and I know Jennifer had made a couple of notes. She wanted to ask you a couple of questions, if that's all right with you as well.

GUY: I do have two other things I'd like to cover, but maybe your questions would be appropriate to take care of those now.

ROSS-NAZZAL: Sure. Some of the things I was thinking about—what impact did the 1978 class and 1980 class have on the EMU when women started becoming astronauts? What impact did that have on the spacesuit and then also the waste management system?

GUY: The waste management system, I think, was always of a design that was compatible with females. The only difference is that the receptacle, obviously, had to be different, but it was really an adjunct to the system. It was on a hose that was used separately from the system. The waste management functions were separated, so as long as you had an appropriate receptacle, I don't think the system had any other subtleties that made it more difficult. Now, obviously, there was a lot of work done to try to find the most efficient receptacle, but the urine is air-entrained in either system, and you need to be able to introduce gas flow to direct the liquid. I don't know of anything else.

Now, the suits, that was a big problem. Suits don't necessarily scale when you're trying to keep a lot of common componentry, you're trying to use the same helmets and the same neck rings and the same wrist rings. They're basically too big for the smaller women. Some of the women were large enough that that didn't make any difference, but there were some that were very small. Initially there was no way to fit those within the sizing arrangements that the suit had.

Very early the thought was that the EVA crewman would be specialized; that the recognition that the spacesuit is an encumbrance, it's basically a pressure system that you have to fight—I'm sure the words I'm using wouldn't please the suit designers, but the bottom line is that you've got this balloon that you keep trying to flex, and it takes energy to flex that balloon. Even with bearing systems, which means you're not flexing the balloon; you're basically

keeping the balloon the same size, but you're rotating it. Even bearings take some amount of force to use the bearings.

The early thought was that the EVA crew people, persons, men, would be on the larger size and would be strong and would be more natural in overcoming the adversity that the suit causes. But politically that was not acceptable, and some very small female astronauts had been selected, and they viewed it as a personal affront that someone hadn't designed a spacesuit for them. There was a lot of work done to try to accommodate the smaller sizes. That probably has continued on after I left. I left, of course, in 1990. But I don't have any feel for that.

But I do know that very early on there was a push to try to develop some smaller sizes. I can remember Anna [L.] Fisher wanted to get in the—I think it's Anna—wanted to get in the water tank to do some neutral buoyancy testing. We took an old suit, Pete [Charles] Conrad's, and Pete was a small person. We cut the ankles out of it, if I remember right, and put it back together so she could use it. Again, some other people would be a lot better at those details. Jim [James W.] McBarron [II] would know the details. But I think that's right. I think it was Conrad's suit. I think we cut the ankles out of it in order to fit her. But there was a lot of activity.

But I guess since this is historical, we thought that what was called an EVA cadre, which was a set of people who were efficient and had the right skill base for doing the EVA tasks, that that would be the better approach, and then we could concentrate on fitting that smaller group better and better, and we could enhance their ability to operate, as opposed to everybody that comes along gets to be an EVA astronaut if they want to.

It didn't seem farfetched to us. I mean, we have pilots. Mission specialists don't fly the Orbiter. They drive in the Orbiter. It didn't seem farfetched that you would have some EVA

crewmen. Actually, we have robotic operators, RMS [Remote Manipulator System] operators. They are trained to operate the arm, and they operate the arm. But somehow it was viewed that if you were a crewman you had the birthright to be an EVA crewman, and there was a lot of push along those lines early on.

But it was merely a sizing problem. If you had the money, you can build a suit for a small person. You might not be able to use the same componentry that you used for the larger people, but you can certainly do it.

ROSS-NAZZAL: Speaking of women, can you give us a sense of how many women you worked with and how that has changed over time?

GUY: I'm never a good champion for the women's underdog position at NASA. I have never seen that. People say that's because I didn't look; I don't know. I've never seen it. When I hired in, the day I hired in, and the group—I think there were two or three of us—there was a female engineer, and I worked with her till I left Langley [Research Center, Hampton, Virginia]. In fact, I actually ran across her at a conference years and years later. She was still there. Her name was Archie. I can't remember her last name, but her name was Archie.

There have always been some women in the workplace, that I recall. There were not very many, but in my graduating class at college there were none. But I know if you just stood in the same line that I stood in, they didn't care what sex you were. You could stand in that line and sign up for that course, and you would have gotten that degree. It seemed to me interest. Now, maybe there was a cultural reason why there was no interest, but it seemed to me that there was an interest that affected the numbers.

Now, you asked about my career. There have always been a few. There's certainly a lot more now, but I've not seen the glass ceiling that people talk about. I've promoted and seen promoted lots of women in lots of different positions. In fact, the first GS [General Schedule]-15 expert that was promoted in this division was a female. The first GS-15 was a female.

This organization was started with a female branch chief, a female deputy branch chief—or section; I guess it was a section in those days. It turned into a deputy branch chief. She later was a branch chief. She later was my assistant. I've had a deputy, a female deputy. Lots of female good engineers right now.

I'm not a good reference for an issue. I can say certainly that there weren't very many; there's a lot more now. I think the roles are legitimately broader. But I think that's because the cultivation, that you need some time. You know, if you say the new project manager is Skip Hatfield—I'm making this up, because I don't really know—but is he the project manager. If that position is deserving, then he had to gain some expertise over the years, and I don't know how long that is, fifteen years or so. I don't think it's fair to look back and say none of the Apollo managers were women. The pool was not that large at that point.

But I think as we go forward, of course, we've already had a female Center Director, [Carolyn L. Huntoon]. I think as we go forward, we will see female project managers. We already have female flight directors. And I think that that's because there's a developed expertise that warrants the position.

That's not to say that there aren't prejudiced people and biased people in the world. I'm sure they're all over NASA, too. But it seemed to me that if you wanted to look for bias, that you could probably find some reverse bias; that you could probably find some people that you

didn't think were seasoned enough to be in the position they were in, just as I'm sure you can find the reverse, that a person was seasoned enough to have a position but didn't get it.

But I'm just not a good barometer for appreciating that as an issue, because I've seen excellent male and female engineers. I've seen and been a part of promoting and providing raises for the ones that deserved it.

ROSS-NAZZAL: What was your involvement with the MMU [Manned Maneuvering Unit] and the SAFER [Simplified Aid for EVA Rescue]?

GUY: Well, that's the last two topics that I wanted to cover. Did you have any other questions?

ROSS-NAZZAL: Well, I had just a couple more. What impact do you think that the Manned Spacecraft Center, [now] the Johnson Space Center, has had on this area? That's something that we always like to ask.

GUY: The local area? I don't really know how to answer the question. I don't think the local area would have existed in the time frame that it did if we hadn't been put here, because it was a source of employment, and then all the people that it employed needed services, and it's there. But if you look at The Woodlands [Texas], it exists, and there's no NASA up there. I think this area would have developed, also; probably not at that same time frame, but it would have developed. I don't know of any unique significance NASA has had to this area, except as an employment base. I really don't.

ROSS-NAZZAL: I just had one other question for you, and I'm not sure if you had any involvement or not. There was an issue that was raised in the 1970s about putting wine on board Skylab. Some individuals in the Crew Systems Division were working on that. Were you involved in that discussion?

GUY: Putting what on board Skylab?

ROSS-NAZZAL: Wine.

GUY: Oh. No, I have no idea. The food, after the medical people left the Life Systems Division and moved over to the Science Directorate, they carried the food with them. I don't really have any knowledge about the food at all. I do know that the Soviets have always had alcoholic beverages on their flights, and that was sort of a big deal back during the Apollo-Soyuz as to whether they would toast each other when they joined up. I guess the rumor was that it wasn't on camera, but they did. I don't know if that's false or not. I have no knowledge, but that was the rumor, anyway.

WRIGHT: Tell us about the SAFER and the MMU.

GUY: There was a significant concern early that the tiles were going to need repairing, and it was much associated with the fragility of the tile and the adhesive system, and we were getting some early debris that was causing some problems, none of which were on the leading edge, which I guess is the root cause of the *Columbia* accident. But the tiles, anyway, were being

evaluated as being something in need of repair, and the MMU was conceived as a platform, EVA platform, that you could fly around underneath the vehicle and stick on or something with some adapter system and repair the underside of the vehicle.

It was an extremely serious initiative. I don't know what was the driver for why it was so serious right then. Probably it was a flight that had had an issue that was serious enough to worry about. But there was a significant initiative. The MMU was then created or begun as a crash program. There were versions. There was a version of the MMU that was put on the Skylab. I guess maybe even Gemini, early, had a unit. And inside Skylab they flew some precursors to the MMU. There was some knowledge out there and a basis for developing one.

But it was put on a crash-program basis, and the Program Office, instead of giving that out to anybody in the Engineering Directorate, the Program Office itself initiated that contract with Martin Marietta, Denver [Colorado]. They put their program manager in residence—I've forgotten his name—in residence in Denver, so he lived there. The theory was you have to have hands-on decision makers, somebody that's right there that if you need a decision, you get it made and you keep moving. We supported that, because it attached to the suit and all, but it was not our responsibility at the time.

Then the repair cooled off. Again, I can't tell you why that happened, either, but it was decided that it was not necessary. The Program Office decided that they would give us the responsibility to finish the program for the MMU. The idea was the MMU was worth pursuing as a vehicle for the crew to fly around in, but it just didn't have a unique mission of repairing the Orbiter. They gave us the project, and we were supposed to take over the GFE responsibility for managing it, and we did.

The difference, though, is that they had talked themselves into a crash program that allowed the contractor to make a bunch of shortcuts that we couldn't sign up for. When we took over the contract, it was very unpopular, but we basically went into a hold. We said, "Cease until we get all the parameters of this project settled out and figure out where we are, what we need to do, and go forward from there."

The project manager who was resident, I think, took it as a big affront that we thought that he wasn't managing the project in the same rigor that we wanted to manage the project. We put our own eyes and ears there, but not as a project manager, but as a resident, and we reinitialized the project after a short time. I've forgotten exactly how long it was; it wasn't too long. Then we managed it from there on out.

But we were much more interested in defining the performance characteristics; finding a way to make sure we met them; test to make sure that they existed. The project was run pretty much as we ran our projects in the division, and it did real well. The MMU was really a nice piece of hardware.

But when we got to the end of the project, we said, "Bring it to Houston. We're going to test it in the thermal vacuum chamber."

They said, "Well, that's not necessary, you know. It's okay like it is."

We said, "No, we don't think so." We paid for them to bring the unit to Houston and to support a test out in Chamber B, and we learned a lot about the system in that test. It was really worthwhile us getting that test experience with the unit. The MMU—and it was only used three times—never gave any trouble at all. It was a very good piece of hardware.

Another thing we did is that we didn't have enough money to keep the prime alive forever in an operational sense. We needed to take ownership of the hardware and be able to

ship it to KSC [Kennedy Space Center, Florida] and fly it without having a big contract at Martin Marietta, because we didn't have any money for a big contract at Martin Marietta. We decided to use a local laboratory that we set up as an MMU laboratory, and we would do what was called "ship and shoot," which said we'd do the checkout testing here, ship it to KSC, and do what amounted to a suitcase checkout there, and then fly it. Then when it came back, it would come back to Houston.

Martin Marietta didn't like that at all. They wanted the hardware to come back to them. They didn't want it to come through Houston. They wanted a direct ship, and of course, it was our contract, so we won.

As I said, we flew three times. The first time was basically a showoff mission. In fact, all the shots that you see with the MMU sort of way off, those were on the first mission.

Then we flew a Solar Max mission, where we were supposed to capture the Solar Max. It wasn't the MMU's fault, but the capture didn't work because the interfaces were not defined by—it was Goddard [Space Flight Center, Greenbelt, Maryland]. Goddard had put some thermal blankets on the Solar Max and didn't keep configuration drawings. They didn't know how they were installed. The way they told us they were installed was not right, so it didn't work. But we were able to capture the vehicle, anyway, with the manipulator, so that worked out all right.

The third time was we had two satellites, WESTAR and PALAPA that had some launch issues. They were orbital, but they were not useful. We went up and captured them with the MMU and brought them home. That's the only three times it was ever used.

When Station came along, a new requirement evolved, and that is if a crew gets loose in space, what are you going to do? Well, Shuttle, it didn't matter. You could go get the crew that

was not an issue. But for the Station, it's not going to go get anybody, if you get loose, you've got to find some way to get yourself back or you're not going to get back.

One of the contractors came up with the concept of SAFER. I'm not sure who it was, MacDAC [McDonnell Douglas] maybe? I don't know who it was. But it was the idea of a little jet pack that you put on a backpack, and it was a good idea. The program manager was Dan [Daniel M.] Germany at that time, and I went to Dan, and I said, "If you'll foot the bill for a small endeavor, we'll build a little SAFER and demonstrate it on the air-bearing floor."

He said it was an interesting idea and gave me a little money, and we put it together and demonstrated it and brought him over and showed him.

We said, "If you'll give us a little more money, we'll build a flight unit and prove it in orbit."

He did. He gave us a little more money, and we flew a—it's called a DTO, Detailed Test Objective. We flew the SAFER, and it was a beautiful flying vehicle. It really was great.

Then after that I went to—I guess Brewster [H. Shaw] had taken over, Brewster Shaw, and I went to Brewster and said, "You're probably going to need one of these."

He agreed, and we built the SAFER and have been flying it ever since.

WRIGHT: Anything else you can think of? Anything else you'd like to add?

GUY: No, not right this minute. No.

[End of interview]