

NASA JOHNSON SPACE CENTER ORAL HISTORY PROJECT

EDITED ORAL HISTORY TRANSCRIPT

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INTERVIEWED BY REBECCA WRIGHT
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WRIGHT: Today is March 24, 2015. This oral history session is being conducted with Paul Hill in Houston, Texas, as part of the JSC Oral History Project, and for JSC's Knowledge Management Office. Interviewer is Rebecca Wright, assisted by Rebecca Hackler. We thank you again for taking time to come to our office and visit with us today. You've been with NASA Johnson Space Center since May 1990. Please, if you would, start out today by telling us briefly how your interest in space flight began, and how that interest led you to becoming a part of the JSC community.

HILL: I tell this story a lot, and I think some people think that I either make it up, or I embellish it some, because it sounds good. The truth is when I was born in Titusville, Florida—actually, I was born in Orlando, we were living in Titusville—my dad was one of the engineers building the pads at KSC [NASA Kennedy Space Center]. I have pictures of my dad standing on a dirt road that at that time ran right in front of the VAB [Vehicle Assembly Building]. My earliest memories were watching rockets blast off out of the Cape [Canaveral], starting with Gemini-Titans. I saw Saturn Vs blast off out of the Cape. I thought everybody's dad worked for NASA.

My older brother and I both learned how to count backwards from 10 to 0, before we could count up, like normally, forward, whatever the right term is, sequentially. We would count down to everything. When our folks told us to go to bed, if we were leaving to go somewhere, we would count down from 10 to 0, every single time. In fact, we would correct our friends if

they did it, and they didn't do it right, and they didn't say, "Ignition, liftoff," at the end of it. I would say it's been in the blood. We always just assumed we were going to work for NASA, because we thought that's what everybody did. I never really lost that, growing up. In fact, I went to [Texas] A&M [College Station], got a degree in aerospace engineering, fully intending to go into the Air Force, fly airplanes, be a test pilot, come to NASA, and be an astronaut. It didn't quite go that way, although it was close. I would say my focus always was on doing space-related stuff.

WRIGHT: Before you got to NASA, you did become part of the Air Force.

HILL: I did. I worked in military satellites, as a matter of fact, spy satellite stuff. It was satellite control and satellite communications, more satellite communications than control, really. Actually, if you read the job description, it sounds very spacey. I'd say the biggest part of what I was responsible for was being in command of the people that operated the satellite system, and carrying guns, and using the guns to kill bad guys if they came to get our satellite system. I probably had a lot more focus on that than I did the space-related stuff.

In fact, I think it was the command and leadership things that I learned and had on my resume from the Air Force that interested Barrios [Technology] and MOD [Mission Operations Directorate] when they hired me, when I left the Air Force and came to JSC, certainly more than the rocket science or the technical stuff. They had technical guys from all over. I'm confident that what got me the job was the leadership stuff, and I'm equally confident that I did as well as I did in MOD because of the command experience and the leadership, more than my technical

prowess. I was surrounded by all kinds of really smart guys, lots of them much smarter than me, so I had to have something.

WRIGHT: I think Chris [Christopher C.] Kraft has said that before, what makes a good leader is knowing that they need to surround themselves with smart people, so there you go. I think that's probably part of those lessons applied early on in life. You mentioned about coming through Barrios. You actually got hired there before you became a full-time employee of JSC?

HILL: I did, and it was partially blind-ass luck, or serendipity. My dad actually at the time was working here in the Shuttle Program. He talked to a few folks, including Chuck [Charles R.] Lewis, who at the time was a senior manager in MOD. I got the interview through the back door, through a friend of one my sisters-in-law, and I didn't really know the details behind how you apply, who the contractors are. I didn't know MOD from any other part of NASA. I was interviewed by Barrios for this MOD job, doing early Space Station Freedom operations development stuff, none of which did I really know anything about. I understood the language and all, but I didn't really know the engineering details.

About the same time, I was offered a job by Ford Aerospace, without an interview. Ford offered to match and beat any offer I got by—I don't remember anymore, 10 or 15 percent—if I would come work for them, also in MOD, but in designing a new [Mission] Control Center computer architecture.

I didn't know what to do, again, not knowing MOD from any other part of NASA. My dad and a friend his sat me down and said, "Look, you want to come to JSC? You want to be a leader? You need to work in Mission Control. Forget that Control Center design stuff, you need

to go to MOD. Go to Barrios. They're going to make a flight controller out of you, and we call MOD, "Operation Head Start." Go work for MOD in flight control, and the rest of it will solve itself." With about that much knowledge, I accepted the job from Barrios and showed up here working in this fledgling Space Station Freedom operations organization in 1990. At that time, we thought we were going to start flying Space Station in about three years, and that quickly started slipping to the right. That was before we redesigned the spacecraft from the old "stick-and-ball" design.

The group that I was assigned to did various ops [operations] analyses like: how many space walks does it take; how much time does it take to connect the various new parts of the spacecraft; what does it take to turn it on; what kind of commands do you have to send; what switches do you have to close to turn on electricity; how long does it take to start everything up; can you get it all done in individual Shuttle flights, and then how do you package that all up; what does a flight-by-flight plan look like?

We weren't designing the spacecraft, but when they gave us the piece parts, our job was to figure out how to put it all together in the scope of individual Shuttle flights, and the equipment required to do it. Aside from that, now, how do we fly it? The Space Station was really designed at the assembly complete stage, and then they carved it up into smaller pieces. Each little bitty piece wasn't originally designed to fly without the full configuration. As we built more onto it, how did that change how we fly it? How did that change how the Space Shuttle flies to and from the Space Station? Solar arrays used to be over here, now they're over here. The docking ports themselves also kept being moved around as we built more.

So all of those little nuances on what it takes to build it, what it takes to operate it incrementally, what it takes to fly Shuttle up to ISS as it changes, flight after flight. The group

that I was in was pursuing all of those avenues. It was a great opportunity for me, having not grown up as an MOD guy. MOD is one of those places where you earn your stripes coming up through the pecking order. Coming here already with some experience but not having been a flight controller in MOD put me in this weird place where although some people thought that I added something, lots of people naturally thought, “Who is this guy, what’s he done? He hasn’t really done anything, because he’s never been a flight controller *here*. There’s *nothing* he could have done anywhere else that could be all that valuable to us.”

While MOD was busy flying Space Shuttles before we were actually building Space Station, I was off with a bunch of guys doing all this other analysis on our own, waiting for the rest of MOD to finally get interested. Once we got close to flying, the rest of MOD engaged by opening the work that we had been doing, and learning how to fly the new spaceship. It was a fun three or four years.

WRIGHT: Yes, that exercise sounds like maybe one of the aspects of it was learning to look at the entire picture, that whole, if one piece changed, another piece changed. Many people sometimes tend to forget that all those pieces have to connect and work together, no matter where they move around. Do you feel like that experience helped you as you started working through the operational phases as well?

HILL: It did. A big challenge that we had was with the folks who worked for the various prime contractors designing and building the various parts of the spacecraft. Frequently we would be arm-wrestling or at loggerheads with those folks, because we would see that in this early stage, when we only have three of maybe five intended computers to control the spacecraft, all the

software that was designed to be there for certain types of control was not there. We didn't actually have a way to turn this piece of equipment on, or to turn that critical function on. We found ourselves going round and round, because the designers absolutely knew their design, they absolutely knew the software. They sometimes were not nearly as aware of which components weren't actually going to be there. They knew what it would look like, say, by the end of year two. They weren't necessarily as aware of what it would look like in the third month and in the fifth month and in the twentieth month, etc.

We were frequently going back and forth saying, "Look, we have read the software, and we've gone through the routines. This is how it works at this stage. It doesn't work the way you guys said it works. It doesn't work like that for three more months, or three more software deliveries." It definitely made us significantly smarter about the little nuances of how the spacecraft operated, and if certain computers failed or certain software had problems in, how that could affect our ability to control the entire spacecraft, because we had to dissect it forwards and backwards so many times.

The design itself changed enough when we went from stick-and-ball to the pre-integrated truss. Then we changed again to the International Space Station where we changed the order in which we put it all together in orbit, and we added the Russians. Then, just adding the Russian systems connectivity was a challenge—how their computer and communications systems connect to ours. We would get it all choreographed, and we would understand how it would all work, and then it would change. I can't tell you how many times we completely re-choreographed every single mission of the entire assembly sequence, in the time from 1990 through 1998 when we finally started flying. I'll bet we wholesale changed all of those ops plans, and most of those ops analyzes that went with them, a dozen times.

We became really good at, like I said, being able to dissect it and look all parts of the operation, all parts of the problem, from just about any perspective. It certainly prepared us well for the unknowns that would come up as we started building and as we started flying. Now for me—I'm going to make this selfish observation—the thing that was good for me was as one of the older heads in my group—as an older head, I was all of 28 years old. I had been a Captain in the Air Force. A lot of the folks that were in my group were less than two years out of school. Because of that, I was put in charge of a lot of these ops analyzes we did. As I would close one out, some other idea would come up with me or my boss or some other guy that was doing much of the same type of analysis. I would latch on to some next really interesting idea, and I would start pursuing some new analysis that we hadn't done yet. For years, I found myself going from one to the next to the next, rarely actually being assigned work from my first NASA boss, Andy [Andrew F.] Algate.

Co-ops seeking advice frequently have asked things like, “Hey, what do I need to do so that I can follow in your footsteps? What's your roadmap that I can now do all the things that you've done?”

One of my secrets was I always had myself busy doing something that mattered, and that my bosses thought mattered. As long as I was busy doing something that was really interesting that my bosses all thought mattered, they didn't assign me other work. I was always doing something that I wanted to do. I didn't really do this on purpose, but frequently I'd start closing one study out, something else would appeal to me, and I would start pursuing that next idea. The boss would think it over and say, “Yeah, we ought to do that. Pull together a team and let's go ahead and do it formally.”

That experience, doing that time after time after time for several years, definitely gave me a leg up in pulling teams together to do stuff. As you start talking to a new team and say, “Hey, look, we need to look at this design this way,” people would go, “Huh, I never thought about that one before. How would we even start doing that?” By the time I applied to be a flight director, I had done that, gosh, half a dozen times or more, on big, Space Station, end-to-end assembly analyses. It’s kind of like I thought when I was a kid that everybody’s dad works for NASA. After a few years of that, I thought well, hell, this is probably what everybody does.

WRIGHT: Yes. Everybody thinks this way, right?

HILL: Right.

WRIGHT: I have to say too you learned a lot about the people you were working with, going from building these teams and moving from different aspects, you learned different ways that different people think. Because I think, as you mentioned, everybody doesn’t think the way that you do, so you had an opportunity to learn about a lot of the people that worked, and learned from them and how they came up with methods of pulling information together.

HILL: Yes, I would say I had two experiences that really stood out in that timeframe. One of them was recognizing that I hadn’t grown up in MOD. Even if I’d come here right out of school, I would have only been here five or six years. Five or six years of being a flight controller and working Shuttle missions is a lot of experience doing that. John [P.] Shannon is a really good example. By the time he had been a flight controller for five or six years, he was picked to be a

flight director. I recognized that I had a lot of catching up to do on Shuttle systems expertise and the MOD way of doing business in the Control Center. I went out of my way to watch who the guys were that when they spoke, everybody listened, the E. F. Hutton guys. Guys like Bill [William H.] Gerstenmaier who in that day was a branch chief in MOD. He chaired a number of the top-level technical forums that I would present my material in, where it would have to be reviewed and approved. Ben Sellari, Robert Galvez, Andy Algate, the guys that in our business as we were working on the hardest things, always had the answers.

I went out of my way to seek those guys out and get tutored at the knee, rather than having to figure it all out on my own. Not that I didn't do any of my own thinking, but we would have a discussion, and I would hear them use terms that I didn't understand. I would look around, everybody in the room was nodding their head, and I thought, all right, there's something I need to learn. I was never shy about seeking out the experts, and getting some help from them to catch up, rather than sitting in the room and not understanding what was going on. If I heard something that I didn't understand, I wanted that to be the only time I didn't understand it. The next time I heard it, I wanted to know it cold. I was surrounded by so many people who could help do that. That was a great experience, or a great learning opportunity for me, and to learn that it's okay to ask, and to get that kind of help.

Much later on, as a senior leader at MOD, that's one of the things that I pushed and pushed on all of the MOD management team, to make sure that we are setting ourselves up so that as the new folks come in, they don't have to spend years trying to redevelop all the things that we went through. Give those guys a head start so that they can figure out the things we have not yet figured out.

The other thing that I learned though was as you said, everybody's a little bit different. I definitely made that observation. What I tended to do though was pay attention to the types of things that almost everybody gets stuck on, and which things they would typically come back to says, "This can't be done." The list of roadblocks or showstoppers was not that wide a set of things. So the challenge became how to pose a question to somebody on a very difficult problem, anticipating the different reasons from across our community for why it can't be done, this question can't be answered, or this problem can't be solved.

Over time, doing these types of analyzes, because so many of them we hadn't done before, and some of them were complicated and technical, I became better and better at how do I present this to large teams of folks and don't end in a place where the entire team just says, "Well, this is not doable, so what's the next thing that we're going to do?"

I learned ways to present those challenges to the team, that instead of getting stuck on, "Holy cow, this great big thing that you want to do is so hard, it's not possible," but instead, "Here's this one little piece that looks really hard, but even though it looks *hard*, isn't actually *impossible*. I think I can solve *this piece*." I learned ways to present significantly larger, complex problems to big teams of people, but in a way that each of them could see their smaller piece was actually doable. Of course, as they would start bringing in the answers to their doable part, all of a sudden, the *impossible* integrated solution doesn't look so impossible anymore. The problem we couldn't become solvable, not because I figured it out, but because the team figured it out in difficult but solvable pieces that fit together.

My experience for the rest of my NASA career looks just like that, one "impossible" problem after another. How do we dissect it? How do you assign the team to start working it, and not bump up against this wall that they can't get around, because "clearly this is

impossible?” Because if it’s impossible, we really are wasting our time trying, right? The thing that I always marveled at is how in the world can we, MOD for NASA’s manned spaceflight, look at something and say, “Well, geez, that looks hard, it must be impossible,” and not try it? Are you kidding me? With the stuff that we’ve done? We’re just not looking at it right.

Let’s figure out which parts of it are hardest, because that’s probably why we think it’s impossible. Let’s just look at different ways to either solve those problems, or let’s not solve those problems. Let’s do it a different way where we can leave that problem alone, and it’s not in our way anymore. For me, it was always a personal challenge. “Really? We’ve become *that* MOD now? We’re afraid to do this thing because it’s hard? Really?” The answer was always no, we hadn’t become a timid MOD. We just had to ask some tough questions differently.

WRIGHT: Yes, reformulate it. During the time you were working on all of that stuff for preparing for the Station, because you had mentioned that it transitioned into the International Space Station, what were some of the thoughts that you guys were working through with those challenges, because now it wasn’t going to be just the Americans, you were going to start having international partners? How were you adjusting maybe some of the plans for the future, based on what little information you had at that time?

HILL: Some folks forget that in the Freedom Program we had international partners, the same international partners that we have today, except for the Russians. But in all other cases, the international partners were already there. In much of the program, not just in MOD, the topic of discussion with the switch to International Space Station and, in particular, the addition of the Russians, was, “Holy cow. They’re in the critical path.” We—the U.S. flight directors, MOD—

are expected to protect our astronauts, protect the spacecraft, get the mission done. But they didn't just give us more international partners. They inserted an international partner that 1) our country historically had trouble getting along with, 2) speak a significantly different language with a significantly different alphabet, which they have no intention of changing for flying, and 3) we have to have to monitor and operate some of their equipment. They have critical life support, guidance, propulsion, and some early power generation equipment. If their stuff didn't work right, or they had a failure and didn't respond correctly, it affected the whole spacecraft. How the heck do *we* manage operational safety day-to-day, hour-to-hour, with that, with this partner, who again historically we haven't gotten along with?

I would say there was great anxiety from the time the shift to ISS started until we started flying about four years later. Much of the focus for that timeframe was in bridging that gap. How do we have a relationship with our Russian counterparts such that we have good confidence that we're all going to do the right things, especially if things don't go well, and we have some emergency, or some failure?

Early on, that was our concern, "Holy cow, we now don't have complete control." We spent lots of time wringing our hands about that. That is a topic of discussion that still comes up from time to time in the ops community. Here we are, more than 15 years into flying the International Space Station, and at the working level those relationships developed and worked pretty well. We had a rough start in some ways, but when you have engineers responding to an actual emergency—you know, the spacecraft is breaking—it's surprising how quickly the politics fall to the wayside, engineers solve engineering problems, and physics is physics, no matter which side of the ocean you grew up on. Left to themselves, the flight controllers and engineering community does a pretty good job attacking technical problems. It starts getting

more complicated as you start adding in the upper levels of management because now various things like agency or national politics and prestige start weighing in.

WRIGHT: During those early days of Shuttle-Mir [Program, Phase I, International Space Station], there was a lot of trial and error for exchange of information, and setting some of those plans. Talk about your involvement during that time period. I believe we understand you were at the Mission Control in Moscow during STS-86, and how you prepared to go there and become a participant over there, and what those lessons were that you brought back.

HILL: In those days, for Shuttle-Mir, we had a large contingent of U.S. engineers in Moscow, in the Russian control center. When I went over there, I was brand-new flight director. I think I'd been a flight director a year or less, certainly no more than a year. It was actually intended more as an orientation for me than it was for me to go over there and actually be a leader and be useful. To the greatest extent, for Shuttle-Mir, our people's presence in Moscow was really for information purposes. Again, some of the relationships for Shuttle-Mir were rocky. Data exchange wasn't as smooth as it was say for a U.S.-only operation. The same thing would be true from the Russian side. You're having to penetrate unlike communication systems, and people who speak different languages. There's all kinds of distrust, some of it for historical reasons. Of course, if we'd been from the same country but different government organizations, there would have been similar kinds of distrust and competition.

There was a lot of that organizational ownership stuff. When one side would ask a question, it wasn't unusual for the response back to be "Why do you want to know this?"

Who cares? Just answer the question! We had lots of that stuff to go through. My main role when I was there at that time was to listen to the discussion and watch how things are going. When the U.S. control center in Houston talks to their counterparts in Moscow, let Houston know when we're not actually communicating, when it sounds like the Russians are not happy with something, it's not clear to Houston what they really want to know, or if we're asking them for something and we're not getting an answer. Observe in person if there's something else going on that's preventing the problem from being solved. Figure it out, and then work with our guys in Moscow who have close personal relationships with the Russians to break the log jam and the information flowing in either direction. Get the ops guys to talk to each other and solve problems. It was largely a nontechnical but a relationship type of exercise for me.

The hard part for me is my experience until then had really been running teams of folks, all of whom knew this is the hierarchy, this is the person that's in charge, and this is the guy that's his boss, and this is the guy that's his boss, and everybody salutes and follows. Engaging with the Russians is not like that at all. It does take a certain emphasis on relationship building and figuring out how do we get around these cultural differences to get this piece of information, or to get this response that we need from the international partner. That was a big lesson that took a long time to sink in with me, not unlike a lot of Americans, but especially American leader types. Especially me.

WRIGHT: Coming back—like you mentioned, the military background, and I know that you were in the Corps at A&M, you definitely had years of this is how we do things, and this is structure.

HILL: MOD is very much like that. Having to accept we need to do this differently, we can't say it just like this, even though this is the way it is. We need to use this kind of subtlety, and we need to go over to this group and get them to help with these guys, who will then help with this guy. Oh boy, it was maddening. It was not intuitive to me, and it took a while for me to get my mind around it.

WRIGHT: It was a good learning platform.

HILL: On the other hand, MOD and the program did a good job with various training for all of the community who would be engaging with the Russians. The concern is not really unique to working with the Russians, but there was a significant emphasis on that relationship because we shared so many critical systems. We were each in the critical path. The Europeans, the Japanese, the Canadians, all very important partners, but in most cases, problems with their equipment or mistakes made in their control centers wouldn't kill everybody. Failures and mistakes on the U.S. and Russian sides had the ability to kill everybody really quickly. Thus, we had a significant emphasis on that, plus NASA didn't have nearly as much recent history having an ongoing relationship with Russia as we did the other international partners.

Because of that, though, we did things like the Russian cultural class, where we had folks come in for several days who were native-born Russian speakers. They would talk about Russian culture versus U.S. culture, and how decisions are made on the U.S. side. How does management engage and approve things on the U.S. side? What does that look like on the Russian side? I took all of those lessons to heart. It was funny to watch the reaction of many Americans who went through those types of classes, because they would either react as if the

instructor was passing judgment on the American side, or they would pass their own judgment. Many would develop well-earned admiration for how much the Russians accomplished with a fraction of the budget. If you went over there and you saw how our counterparts lived over there, compared to the relative luxury and wealth that we live in over here, it's astounding. It's humbling to think, again, that they accomplished all the same types of things that we did with so much less.

Because of that, a lot of the Americans that would go through these cultural things would "go native" on us. They would embrace this Russian way of looking at things, because "clearly, for us to do the same thing on the U.S. side, it's so easy. We really can't be proud of it anymore." I never bought into that. What I did pay lots of attention to is, just what those cultural differences are. Because if you're going to negotiate with a Russian, or anyone—and this was the actual goal of that type of experience—and you know they think differently and make certain subjective decisions or judgment calls differently than we do, you'd better understand how they pass judgment. Otherwise, you're not going to be able to influence them. Just pounding the table and demanding that they do the math the same way we do won't do it.

I took all of that stuff to heart. Early on when I went over there for Shuttle-Mir, I don't know that I used a whole lot of it, because again I was largely a figurehead or spokes-model. But not long after that, we were in detailed negotiations, finalizing the initial flight rules for no-kidding, operational instructions for the International Space Station, the way we flew Shuttle to and from, and the way we flew Soyuz to and from. I was the guy who led the development of all of those initial flight rules, and I led the negotiating and the signing rule by rule, line by line, with a couple of experienced Russian flight directors. By the time I was negotiating the ISS flight rules, Shuttle-Mir was a great experience to have behind me. From the relationships I built

by being over there, getting my toe in the water of negotiating with Russian leaders at that level, understanding the operational ramifications of our cultural differences, all definitely helped me when it was time to start signing on the dotted line. Then things got much more serious.

Now you've got some Russian flight director and a U.S. flight director who are formally putting their name down, saying, "This is the right way to fly. If it's not, it's on me." As for the cultural differences, on the U.S. side, it's not that big of a deal. My attitude was, "Okay, I wanted to be in charge, so give it here. I'll review it, and I'll talk to our guys, make sure it's right, and I'll sign." On the Russian side, they are much less likely to volunteer and say, "I will sign my name and say it's my fault, and everybody can blame me." Taking on that kind of formal accountability just has different ramifications there than it does here. But, all of the earlier experience made me much better prepared for the role in signing off all of the ISS flight rules.

WRIGHT: Would you elaborate a little bit more about the complexities of what it took to get to that part where they sign the dotted line? Because I'm sure it was quite a process of back-and-forth, and wording, what words you don't use, and how you even identified these are the essentials, and these must be done.

HILL: Yes, I would say we had mixed success. It's interesting, what's important kind of depends on where you sit. There were a number of terms that we would change. In fact, you could look through a lot of the Space Station Program's documentation now, and you will see references to the "Flight Program." That's not an American term, we never referred to the Flight Program, that's a Russian term. We found out that as you're negotiating flight rules or

procedures, or a protocol (which is nothing more than formal minutes to a meeting where you decided something) if we would just use certain Russian phrases, then there were some things that we'd been arguing about that more easily resolved. They'd say, "Oh, that's what that is, that's the Flight Program, well, okay, we'll sign that, sure. Of course we'll do that." The only thing we did was change a term. We learned some things like that.

Some of it is just complicated technical engineering work. The Russians are building power systems, guidance systems, life support, all the systems I said before. They're building all of these different spacecraft systems. The U.S. is also building most of the same. Then we planned to install and activate them. Some of them connect physically or electrically. Power system to power system literally had wires that plug into each other. Some, like the life support systems, don't necessarily connect, but one affects the other one. If the Russians over-pressurize something, it affects our side, and affects our life support systems, and vice versa. They can put oxygen in the atmosphere, we can put oxygen in. They can take bad stuff out, we can take bad stuff out. We can each also put bad stuff in.

We had to evaluate system by system to make sure both sides understood every situation. For example, if we have this kind of fire, we're going to turn off all of this equipment for these reasons. You would have somebody on the U.S. side or the Russian side stand up, "Oh my God, why would we do that? We just had this fire, you can't turn off the atmosphere control systems."

"Well, yeah, but we've got to turn this stuff off, because it feeds the fire."

"Well, yeah, everybody knows that."

"Well, yeah, everybody except for you, because you stood up and yelled about it." We had argument after argument, largely like that. Maybe argument is not the politically correct word, but it's accurate. Over time, even though it looks inefficient, we learned it was frequently

more effective to we would generally go off on our own and decide, in these types of situations here's what the operational response should be. Then we would throw it over the fence to the Russians, who would look at it and generally object like hell, because it's not what they would have done. Then we would get together in a meeting argue line by line. Which things they wanted to change, which things we disagree with? We would do that over and over and over, system by system, emergency by emergency, failure by failure, to make sure that we all understood how to do it.

But there really wasn't a cleaner way of doing it. You could argue that we could just pull some Russians in with our guys and just do it all as one great big old team. But with the cultural differences, with the fact that we were separated by nations and agencies, that one-team development notion was just undoable. We'd write a little, give it to them, they would barf all over it, and we would get together and argue about the things that they didn't like. We would update some more. The same thing would happen in reverse. Sometimes they would send us something, "We've decided that in this scenario, this is what the operation would look like."

Our guys would go, "Oh, my God, why would we do it that way?" We'd commence arguing back and forth until we'd get it all written down. Then we would go and do joint simulations together, where we'd plug the Russian simulator into our simulator, and they would make some decisions while we were flying, and we'd make some decisions. Afterwards, we'd have to go back and change our previous agreements based on the exercise. The really maddening part, and I'm sure it was just as maddening for the Russians, was we'd get through one of these, and then we would argue about some part of the procedure. "This shouldn't be like this, we should change it to look like this." We had just spent two weeks arguing about that very thing. The way we did it was the way whichever partner is now insisting we change it. We had

changed it to the way we did it in the simulation at that partner's insistence, now we're going to change it back. Oh my God. We had that experience for years, until we started flying.

When we started building and flying ISS in 1998, we had many more years to come where we were adding on more Russian and more American components, and then the other international partners. That experience of write a little, review, get together and haggle over the stuff we don't agree on and then go back and try to write it and make it look the way everybody agreed, that went on throughout the entire assembly process. From the outside, you'd never really see it because all of that was going on in the background—it would be difficult for us to explain how complex that was, and how much harder that made building and flying the Space Station over that timeframe. What do you see in the news? What do you see on TV? We flew some Shuttle, or Russia flew another Progress or Soyuz and the new thing was attached, and there were astronauts waving inside the new module. How hard can it be? You just have no idea the hours, weeks, and months of engineering and debate and the back-and-forth that went on to be able to make it all happen.

WRIGHT: If you want to see the word tedious in action, I guess that was what it was. I don't know how you survived it.

HILL: Oh yes. The hardest part was before '98 when we started flying, because unless you're faced with, "okay, this piece of equipment is flying next month, or we're going to fly this astronaut crew in six months, and they have to do this then..." you can keep arguing about everything indefinitely. From '94 through about '98, I would say we did a whole lot of arguing

round and round on those things, because we could. Once we started flying, we had to calm down and start only rearguing about the stuff that really mattered.

WRIGHT: The schedule became the driver, or the incentive, to get that issue completed?

HILL: Right. That's true in any engineering endeavor. In NASA, this became a political bugaboo, first with [Space Shuttle] *Challenger* [accident, STS-51L] and then with [Space Shuttle] *Columbia* [accident, STS-107], this whole thing about schedule pressure. The reality is, you're spending this kind of money and you're committing real engineering resources. There *has* to be a schedule. Otherwise you will just keep spending the money. You will keep studying it forever, and not do something. You have to pick a line in the sand and say, "This is it, guys. We're going to go do it then." The hard part as you're approaching that line in the sand is to know when there is some significant problem you haven't solved adequately. As much as you want to commit that operation on that day, you're just not ready, you can't do it. But you still have to pick a day and use that as the target to force everybody to only fight the things that need to be fought.

WRIGHT: Did you have a lot of turnover on your teams that were working on these issues, for whatever reasons, that they were moving on to other projects, or they were getting moved up and into the organization? If so, did that cause an issue if you had to start over with somebody else?

HILL: We never—I shouldn't say never. I don't recall having significant issues with losing so many of just the right people in some technical area that it was going to grind us to a halt, or

force us to go back and relearn something, because when those people left, we just had corporate memory loss. I don't recall that happening, although it was always a worry, especially as we were ending the Shuttle Program. We did have occasions where we got awfully lean, where we only had a few folks who had expertise in certain technical areas and we had to bring other people in to get schooled up. From 1990 through '98, when we started flying, we definitely lost a lot of really good people who went through that early ops analysis. Many of them were intended to become the first ISS flight controllers, but they couldn't hang in there the whole eight year period. Eight years of studying, choreographing, and re-choreographing Space Station assembly operations, rearguing about the same thing for each new design, that took its toll, and we lost a lot of folks. I still look back and can call many out by name, and I think, "Oh my gosh, I wish that guy had stayed. He would have been tremendous." But we had really good folks still coming in to take their spots.

By the time we started flying, I would say that kind of attrition definitely slowed down, because once we started really doing it, it was hard for folks to let go and not be part of it. You may have just worked this *one* flight, and you were part of getting *this* part of Space Station installed and activated. "I've got another one I'm working on in six months, I'm not leaving before *that*. I might be really mad about something, or I'm really tired, this job is burning me out, but I can hang on for six more months. Because *I'm* the guy that's been writing that procedure for six years, and by God, I'm not letting anybody else screw it up, I'm going to do it."

There are folks today who are still flight controllers and flight directors who were part of the very first cadre of flight controllers in the 1998-1999 timeframe. There's a few of those folks today who go all the way back to 1990-1993 timeframe, in the early days when we were really

just starting out in Space Station development. Even more of the folks that made it who were here for the first ISS flights in '98 and '99 stuck it out and are still there to this day.

WRIGHT: Along with everything else you were doing, you were also being trained to become a flight director.

HILL: Yes, I was selected to be a flight director in '96, which is funny. I applied in '95, only because that's when MOD asked for applications. When I applied, I had never been a flight controller in MOD, and just submitting my application offended some people in MOD, especially managers. First, most of them didn't know who the heck I was. I wasn't part of flying Space Shuttle, I was off doing this Space Station thing, which a lot of the MOD management at the time looked at like, "Well, someday it's going to be important to us, but today, it's a paper program, it doesn't matter. We fly Space Shuttle. Space Shuttle is a real spaceship." Here, I apply to be a flight director, and they think, "Who is this guy? Why does this guy think he's qualified to be a flight director?"

At that time I was a working troop still. I think I had been an acting group lead a couple of times, but otherwise I was not an official manager of any kind. My division chief pulled me in and he said, "What are you hoping to accomplish?"

I said, "Well, I figured I would apply. They don't have to pick me."

He said, "Well, you haven't done any of the right things. You need to be a flight controller first."

I said, "Well, okay, let me transfer to another division, I'll go to one of the Shuttle flight control divisions and work my way up. Nobody has to give me a head start or anything. I'll go

do that, rather than this ops analysis stuff that I've been doing. I've been doing what I was assigned to do originally. If this isn't good enough for MOD, then send me to do the work that you guys think is good enough, and let me sink or swim doing that. I'm not telling you that clearly I'm the best guy there ever was, or clearly I should be a flight director. *You* guys opened the applications, all I did was apply. Why is everybody so mad at me?"

He said, "Paul, you're never going to be a flight director in MOD. You haven't done any of the right things. Besides, some of the work that you've done, you've ruffled some feathers in MOD, because you don't know your place." Which is true. I don't know my place. I didn't then, don't now. I didn't really understand why we would want our people to "know their place," for starters. My division chief, who was actually three levels of management above me, clearly did not agree with my perspective. He clearly believed I should know my place, and stay in it. He told me so, "When this flight director selection is over, you're not going to be selected. We're going to assign you to other work that you're never going to see the light of day again, and you're never going to get selected, because I don't like your attitude. You just seem arrogant to me." Almost direct quotes, as close as I can remember anyway.

I thought, "Wow, I thought I had been doing good work here. Now I've offended this guy who I thought was actually proud of the work that I had been doing *for him*."

I ended up getting interviewed, which just in itself was a big deal because only a subset of applicants are interviewed. When I got the interview, oh the buzz went through MOD. "Can you believe they're going to interview that guy?" Then I made the final cut with five others, which I did not know at the time. All five of us had to go to Building 1 and have a private interview with the Director and Deputy Director of MOD. I didn't know at the time, but that had never been done before.

When it was all over, I was called in to see the Chief of the Flight Director Office, and the five of us were told we were the new flight directors. Not long after that, I found out that the reason why all of us had to be interviewed by the Director of MOD was because he wanted to interview *me*, because he had heard some of these things about me not knowing my place. The experience I had with the Director of MOD at the time, who was a fellow named John [W.] O'Neill.

Funny in the retelling, the way Milt [Milton] Heflin would say it to me later is, "It was an asshole test." The Director wanted to talk to me and find out if I knew who the boss was. Was I going to do what I was supposed to do for MOD, or did I think I was the smartest guy in the room, and I was going to do whatever I wanted? Not that that was an uncommon behavior amongst flight directors, let me tell you. Because some of the MOD management guys didn't know who this guy was, and how dare I apply, and the fact that my own division chief thinks that I'm too arrogant and should never be allowed to be a flight director, plus I didn't grow up right anyway. Unfortunately for them, my colleagues all had to go through the same asshole test that was intended for me.

In a conversation a few years later, the fellow who at the time was the Deputy Director confirmed it and added, "But it wasn't just you. We were also worried about Mark Kirasich."

Immediately when I got to the Office, Jeff [Jeffrey W.] Bantle, who was the Deputy Chief of the Office, pulled me into the Chief's office. He and [Alan] Lee Briscoe, who was the Chief of the Office—the two guys that picked me—sit me down, not a week after I was selected, and say, "Paul, we don't think you're ever actually going to get certified. You know, guy, we were afraid that you have led so much of the development work for Space Station ops that if you got mad and left because we didn't pick you, there's stuff that we didn't have time to reengineer

that we needed to know in order to start flying Space Station. We selected you to protect the organization from memory loss, but we don't really think it's going to work out because you didn't grow up right. What we're going to do is have you go off and be a RIO [Russian Interface Officer] for six months. Work a few Shuttle-Mir flights as a RIO."

A RIO is a position in the Shuttle [Flight] Control Room, whose job was essentially the liaison between the Russian flight director and the American flight director. As things were happening, and the American and Russian flight directors didn't have time to chat each other up because they were busy running some operation, my job was to keep tabs on what the Russians were doing, whisper into the ear of the American flight director, and periodically go to the Russian flight director and ask questions, or tell them, "Hey, the American flight director needs X, Y, or Z."

The theory was: "we'll have you go do this for a few flights, while we engage you doing some other work and start putting some of the other new flight directors around you, so they can pick your brain and learn all this stuff that you know, so we can finally get rid of you, because you didn't grow up right. You'll go do this Shuttle-Mir thing, and by the way, our expectation is, we'll discover in this Shuttle-Mir RIO job that you don't have the chops for it. Because the Air Force is one thing, but *we're MOD*, and *we're Mission Control*, and *what we do is different than what everybody else does.*"

It didn't go that way. As it turns out, the training I had to do to be allowed to be a RIO left maybe 20-30 percent more in the training plan to be certified as a Shuttle flight director, short of running simulations, running real flight control teams. I thought, what the hell, I'll just go ahead and do all the rest of it. I'm not going to ask, I'm just going to do it on the side, because it can't be bad to be more knowledgeable. Because again, *I knew* I was playing catch-up

with all my peers. *I never* really thought I was going to be a Shuttle flight director. I figured I'd be a Space Station flight director, but that this would help me be a better Station flight director.

About six months later the Deputy Chief came down to my office, sat down, and said, "Hey, it's come to my attention that you've gone through the entire Shuttle flight director training flow."

I said, "That's right, but I did it all on my own time. Every hour I spent in a class or anything else, I made sure I stayed longer, and that I went over my 40 hours, or whatever, but MOD didn't pay for any of that, I did it all on my own time, all the workbooks I read, and everything. I took all of it home, did all the studying at home, did none of it on the job." Because I figured I'm about to get chewed out, for doing this thing I wasn't supposed to do, because I'm arrogant, I don't know my place.

WRIGHT: And you weren't raised right.

HILL: And I wasn't raised right. Actually, what I was trying to do was make up for not being raised right.

My boss said, "We're really disappointed that you did this without asking permission. But, we're in trouble. We've had a couple of flight directors leave. We're hurting. We're short a flight director on a flight that's coming up in a few months. You start simming [running simulations] in two weeks."

And I thought, "Oh my God, what do you mean I start simming? I wasn't a Shuttle flight controller, I was just doing this to get more knowledge. I didn't think I was actually going to *be* a Shuttle flight director." Two weeks later, I'm on console, running the flight control team as a

Shuttle flight director, scared to death because again, I was very aware that I hadn't grown up right, and that all of my peers that became Shuttle flight directors had years of experience as Shuttle flight controllers to rely on. Here I was, almost doing it as a book learning exercise. Now, I'm plugged in and in charge of the team? Oh my God, terrifying.

I'd say my first three or four sims were probably the most scared I'd ever been, including the time I was in the military carrying guns in the field. Oh, terrified. Mostly, I was terrified I was going to let the team down. They're all going to find out, "See, we shouldn't have picked this guy." I was less worried about them finding out I wasn't ready than just not being good enough for the flight control team. Over time, it turns out I picked it up pretty well. Part of it was those darned MOD flight controllers are good. Even somebody like me, who hadn't grown up right, could come along and, if it sounds like you're doing your homework and you're leading the team well, it's amazing how much they would forgive and help us with things, things that we didn't know very well, how far the flight controllers would go out of their way to tutor us and get us there. They *want* the flight director to be Chris Kraft and Gene [Eugene F.] Kranz. They *need* a leader that they can actually look up to, and they will help make it happen, if you treat them right. Fortunately, I did. Arrogance and bad upbringing notwithstanding.

A few months later, I was certified as Shuttle flight director. In the end, I was the first in my class of 5 to be certified as a flight director. By the time the rest were certified as Station flight directors, I'd probably worked half a dozen Shuttle flights as a Shuttle flight director. I don't say that in the way you could interpret it as, "See, I was so much better than those guys I was selected with." That's not how I look at it at all, I didn't look at it that way then either. But I'm pretty confident none of them were told they hadn't grown up right, and they were never

actually going to succeed. So it did stick in my head that as the guy who was told I could never get there, I actually was certified and flying Shuttles a year later.

The funny thing is, about a year later, that same boss sticks his head in my office and saw on my whiteboard that I had written out summaries of all of the Shuttle entry flight rules, especially emergency-related flight rules, things that would make us jump out of the sky. It was my way of testing myself and making sure that I had committed all of it to DNA, so if anytime I was flying Shuttle, I found myself in the position where we have to land right now, I didn't want to have to go do my homework, I wanted to know it cold, just like my peers who had grown up practicing. My boss said, "Paul, I know we let you be a Shuttle flight director, and you're doing a great job, but you are never going to be an ascent/entry flight director." All could say was, "Really? Are you guys going to keep saying this to me?"

In fact, I did not go on to be an ascent/entry flight director, although it wasn't because they didn't allow me to. If I had pushed, they would have let me, but it would have ruffled some of the same feathers again. But, I was so busy working the Space Station stuff, I had to choose. I wasn't willing to give up the Space Station assembly I had devoted so many years to, to be an ascent/entry guy. That was a tough trade, but we also had other flight directors who had less to learn than I would have to be ascent/entry flight directors.

WRIGHT: You've got to sacrifice something, huh?

HILL: It was funny. It was funny, yes.

WRIGHT: STS-87, I think, was your first time that you worked as a flight director?

HILL: Yes.

WRIGHT: November of '97?

HILL: I'm sure there were a couple of flights before that that I did on-the-job training. But STS-87 was the first time I was ever actually on console as a fully certified flight director.

WRIGHT: Your name listed as such?

HILL: Right. Right.

WRIGHT: What are some of your memories of being in that position for real that I guess 'never' had finally arrived?

HILL: By the time we flew STS-87, I had done it so many times in the simulations that I had gotten over that. Really controlling the Shuttle for the first time in flight was not significantly different, or a real different experience for me, because our simulations are so lifelike, and are so much scarier. By the time I did it in real life, it was really just doing what I was pretty well rehearsed at doing, with one exception. That exception was we always started the new Shuttle flight directors with the planning team, which is when the astronauts are asleep, and we're literally working tomorrow's plan with the flight control team, trying to get it all ready to go and printed onboard the Shuttle, before the astronauts wake up in the morning. They wake up, see

the new plan, and get going. By the time the astronauts get going, one of the old head, flight directors comes in to replace the new guy, and now he's in charge. The idea being that the planning team is easier for new guys because we're not doing anything active with the spacecraft.

I always marveled at the fact that we looked at it that way. Bad stuff could still happen while the astronauts sleep. You still had to be good enough to handle it. Further, back in the day, it was the planning team flight director who was on console while KSC filled the external tank and we prepared the Shuttle to launch. Then the ascent flight director, the guy who was going to fly the spacecraft for the launch would come in a few hours before the launch, and the planning shift flight director would turn the Shuttle over to them. But the planning team flight director oversees all the preparatory stuff, while KSC is turning the rocket into a big bomb. The very first shift I ever did as a flight director was that – the only thing we *never* practiced as flight directors.

Here I am running this prelaunch, planning team for the first time. The launch director at KSC is calling me on different loops than we are accustomed to talking on, and I'm saying, "Oh, shoot, I know I'm sounding tentative." Of course, everything I'm saying is going out on intercoms all over JSC. Every flight director, most MOD managers are listening to me back in their office. It's also all going out on big speaker boxes at KSC.

One of the things that we did during this shift was we tested something called the abort switch. The abort switch is a button that the flight director or FDO [Flight Dynamics Officer] could push to signal the Shuttle commander, "You're not going to make it, you need to abort the launch right now."

We would test the abort switch during the prelaunch count. Crew is on board, the Space Shuttle is waking up, you're getting ready to launch. The FDO and the flight director would each push the button, which would turn on a light in the Shuttle cockpit. We had problems with the software, it was always a pain because it had to work with different computers in the Control Center, it had to talk to a computer at the Cape, it had to talk to a different computer at Air Force Safety Facility, and we forever had problems with it in those days.

When we did it, we were talking to astronauts on the Shuttle, so as I said, it was going out and God and country could hear everything. As I took each step, I'd tell the astronaut what he should be seeing in the cockpit, "ASP, I am now selecting flight director abort switch number one." What ASP was supposed to say is "I have a good light." Then I would disable it and test the other one. FDO would then test both of his, and then we'd be done.

On this day, I'm following the procedure and test the first switch. The astronaut says, "No response."

"Let me try the other one."

"No response."

As we're doing this, I'm holding down the talk-button on my headset, so everything I utter is going out to everybody, and not just flight directors and managers at JSC and KSC. Hundreds of people from NASA and the public at the Cape that are hearing this. Since the most important action I was going to take on this shift wasn't working, I say, "Shit! Shit! Shit!" And it's broadcast right out in the open.

To make it worse, whenever I was in deep thought on console I had a habit of holding the mic button and clicking it like a nervous tic. On the normal flight director voice loop, if you do that it's no big deal, no one hears it. On the air-to-grounds loop I was using for this test, every

time you click the mic you generate that beep the public knows so well. Dididididididididi [beeping sound]. Again I say, “Shit! Shit! Shit!” I’m thinking, “Goddammit, who is doing that!” It’s me. It’s all going out, cussing and beeping and all. About that time, the phone rings.

“Paul, this is [N.] Wayne Hale,” irritatingly calm while I was beside myself (over something that wasn’t really a crisis.) Wayne was, at the time, the head ascent entry flight director and in his office, listening to all of this. He, by the way, was also the guru on this particular software that’s giving me fits. Now in anticipating that there was going to be problems with this software, do you think he was actually there in the room with me to do it? No. He’s listening, anticipating a problem. Now, he’s heard me cussing out on the open air-to-grounds to the entire world, “Is there a problem?” I commenced cussing more on the telephone. We (he) got it all figured out and never lectured me about the language.

WRIGHT: That’s good news. You chose Atlas, I believe, as your sign?

HILL: Yes.

WRIGHT: Give us the background on that, and why you chose that.

HILL: A few years before, I had read [*The*] *Fountainhead* and *Atlas Shrugged*, written by a woman named Ayn Rand. I became fascinated by her philosophy, absolutely captivated by everything she wrote, both fiction and nonfiction. I chose that call sign as a reference to *Atlas Shrugged*.

WRIGHT: That's interesting.

HILL: I'll tell you one of the other most nerve-racking experiences I had as a flight director was the tradition we have after our first shift on console to announce our new, flight director call sign to the whole team. The flight controllers don't care. Only the flight directors themselves really care, and we don't use the call sign for anything, except amongst us. In "the club," we all know who everybody is. That's really the only thing it's used for, and yet we have always insisted on giving this little speech to tell everybody what our call sign is. That would probably be one of the most nerve-racking experiences I had as a flight director. Getting my team over on a private voice loop that I could tell them this heartfelt, emotional story.

I thought, "Give me a fire in space, or a cabin leak or something that I can work with these guys, and I'm right on it, man, steely-eyed missileman." Now I have to talk to them about this stuff, and tell them what's important to me, and why I chose this—oh my gosh, it was terrible. Most flight directors would tell you the same thing. Not everyone. There are a few that are more comfortable talking about that stuff than others. Actually, as I got older I could have given that same speech without nearly the same amount of trepidation, but at that time, yes, it really bugged me.

WRIGHT: It was a milestone for you, it sounds like. While we're talking about not cookie cutter, one of your classmates was Sally [P.] Davis, which was only the second female flight director at the time. There had only been one before. Was that a different aspect of your culture, working with females, because you had come from the military and then been so close working in the

environment you had? Was that something new you had to get used to, was having peers and colleagues on the same level as you that were female?

HILL: No. Actually, it was not at all. My first boss in the Air Force was a woman. I had officer crew partners and senior officers who were women. I couldn't even name them all. It just wasn't an issue, or even noteworthy that they were women. By the time I was a flight director, it really wasn't an issue in MOD either. It's all about being a hard-charging steely-eyed missileman, or missilewoman, as the case may be.

Really, that's all that mattered. Do you have the chops or not? Yes, that wasn't a big deal for me. When I became a flight director, Linda Ham was the first and only woman who had been a flight director to date. Sally Davis was the second. For a while, you could easily name the women flight directors, like the next couple were Kelly Beck and Cathy [Catherine] Koerner. It gets fuzzy after that, because so many women rose to that level after them, and they were just good flight directors.

Years later, as the Director of MOD, there were a number of occasions when something would be going on with Space Station, and the "A-Team" would come running—I shouldn't say the A-Team, because our folks were all really good—but extra hands would be running into the Control Center to look at data and compare notes with the folks on console. In general, when that would happen, you'd have multiple Station flight directors all huddled together, 900-pound gorillas all talking about the problem, and what we need to do. Just as a sign of the times and how far we had come, I remember looking at the TV in my office and thinking, "Okay, I see five flight directors there. Ah, we've got all the best ones there." Then it occurred to me that "the

best ones” I was referring to happened to all be women. It occurred to me later, “Wow, we have come a long ways.”

These women got no head start, no shortcuts to the front of the line. They earned it the hard way like anyone who came before them. Fortunately, of those that I would look up and think, “Wow, I’m glad that gal is there,” we screwed up and we promoted several of them into senior management so they could help make more leaders in their own image. Some of them, like Dana [J.] Weigel, got promoted up and out of MOD, which overall was good for the community. I hated to lose her from MOD, because my expectation was that Dana was going to be the first woman Chief of the Flight Director Office, and it had nothing to do with her being a woman either. That’s the evolution I was always so proud of. People, like Dana, or Ginger Kerrick or Cathy Koerner or Kelly Beck, who made a difference and left their fingerprints all over how we fly in space, that just happened to be women. They’re some of the best that we *ever* had.

When I look around, much of the rest of the Center, or the Agency, is off looking at how to address discrepancies in various diversity numbers. I get that it’s a challenge. I’m very proud of the fact that MOD figured out how to fix things like that in our normal way of doing business, without having to give anybody a head start. Look at these giants that came out of it.

WRIGHT: I’m going to make a loose segue with the women by talking about Chandra [X-Ray Observatory], because Eileen [M.] Collins led that mission to space, but yet you led the independent team across NASA to determine that the space telescope was ready to go. Talk about working on that science aspect of that. So many times as observers from the outside, people look at space as putting humans into space, but they forget that they have things to do up

there, including special projects, like these observatories that are still working so well for what's going on.

HILL: I'll tell you, the thing that's interesting about the role that I had with the Chandra Telescope and that readiness review was pretty much along the lines of everything I did as a flight director in MOD. It really wasn't science-related, which doesn't mean that the stuff that I did at MOD didn't have any scientific benefit. It just wasn't our role or my role. For flight control stuff, for flying Shuttle or building International Space Station, I stayed one step back from all of the science and the international cooperation—yes, okay, these are great. But *my* job was to get it built, fly it, make sure we fly it right, and don't break it. If somebody else wants to put payloads on that yield good science, hey, more power to them. They can't do any of that if we can't fly this thing. That's *my* job.

For a very short study, that was also my job for Chandra Space Telescope. They were about to ship the spacecraft from the plant to the launch facility at the Cape, to start buttoning it up and get it ready to fly. They had had a lot of development issues. The program manager decided he wanted somebody else that's not in the program but that has experience in this kind of work to look over everything that they've done in development and testing, and assess readiness to before it ships to Florida. Because once it goes, we're launching it as is. If there's anything that needed to be fixed, we had to do it while the spacecraft is in the plant. NASA didn't want to spend all this money to then throw a spacecraft into space that didn't work.

The science part of it, like in my MOD work, was of interest, but in the end, my job was: How did they build it? What kind of testing did they do? What did they not test well enough? Which problems did they have during manufacturing or during testing did they not resolve

adequately, that there was still some lingering doubts that the satellite won't work when they launch it? That was my whole focus. Actually, it fell right in line with all of the things that I had done for years in analyzing Space Station assembly operations. It was like another one of those. I just didn't have all of the same familiar designs and systems to re-choreograph. It was some new thing.

It was a few weeks of reading design and test data, getting comments in from various folks in the team that I pulled together to look at it. Then it was several days in California going through it in detail with the folks at JPL [NASA Jet Propulsion Laboratory, Pasadena, California], who designed the spacecraft (if I remember right) and were responsible for the testing in the first place.

That was a heck of an experience, also humbling because there was a fellow out there named John [R.] Casani from JPL who is one of the Chris Kraft, Gene Kranz figures from their world. I didn't know him from Adam. (In the manned spaceflight business, we're definitely very focused, and we have tunnel vision on our really hard business. To a certain extent, we think it's the only thing that matters. Anybody else's heroes doing any other stuff, yes, whatever. That's not what I do. I do *this* thing.) But John is justifiably a God in their world – and anyone who didn't think so, should have. I bet it didn't take me an hour with him to realize as we were talking about things, and I realized, this guy is not like everybody else. Who is this guy? Oh my God, was he good. He was old enough to be my dad at the time, and imminently patient with this aggressive, young flight director guy from JSC, who clearly knows everything, and keeps picking on things as if his guys hadn't done a good enough job. He never said any of that. Actually, there was many of those conversations I had with that team, and with him in

particular, that I've looked back on over the years and thought, "Oh my God, I can't believe he let me live after saying that."

WRIGHT: I'm sure he appreciated the intensity of which you took your project.

HILL: It was a good review. We gave them some things that they took seriously and responded to and addressed in their readiness before they shipped the satellite. I would say for the most part, they were ready to go. I would put them at 99.5 percent already ready to go, and they might have had a few additional things they did as a result of our study.

WRIGHT: Tell us about all of the preparations and the readiness that you went through to get ready for your first lead flight in July 2001. I believe it was for STS-104. That was your first time to lead?

HILL: STS-104 was my first Shuttle lead. I was a lead Station flight director on the second flight to Space Station, second and third, and the increment in between.

WRIGHT: Do you want to talk about that one first?

HILL: I would say my most important preparation to be a lead flight director for Shuttle and Space Station was the same. Most of my preparation for being a lead was the effort it took for me to be good enough to be certified and able to run the team in the first place. By the time I was assigned to be a lead, I had already been leading the planning of all of the Space Station

operations since I was a midlevel engineer in the early '90s in MOD. Working as a lead Station flight director and even, to a certain degree, as a lead Shuttle flight director, was just the culmination of doing all of that other lead work. Rather than just doing all of this analysis and planning as a leader, before some flight director takes it over, stamps their name on it and says, "Hey, I'm in charge of all of this," I was able to be the flight director, take it all the way through flight, and be in charge of this stuff I had been planning for years. From that perspective, it wasn't entirely different.

The difference though, of course, as the lead flight director, by the time you fly, you've spent months—and in some cases like for the Station flights you might have spent years—working with the lead flight controllers, getting the plan exactly right, working different operational problems either to get the design changed, or change how you're going to do a spacewalk or a robotic operation. You've spent so much time doing it pretty much left alone by the whole community. In the last three to six months before you fly, the rest of the community starts paying attention, and they start telling you all the stuff about it that they don't like. "We want you to change this, we want you to change that, we want you to do this first, we want you to do that first. We don't want you to do this one at all, we need to do more of this."

It makes flight directors crazy, because, "Where the hell have you guys been? We've been sending the flight plan and procedures out for review, and we get nothing. Now we're about to fly, and you're telling me that my thing is wrong? You kidding me?" For all flight directors, and this is true still, the response is that classic, "You're telling me my baby is ugly thing. I've built this thing, I raised it from a pup, and you're telling me it's not going to work? Now we're going to go to war. I'm not changing it for you sons of bitches."

The last few months before you fly always turns into hunkering down and defending the plan. Plus, it's not unusual as you get closer the program decides, "Hey, we didn't think of this, or something's changed. We now need you to do something different on this flight because of this other stuff that's out of our control." As a lead flight director who is ready to fly, I don't want to do "something different." We've just been preparing for months to do *this* thing. We've done all the sims, we're ready to fly *this*. Change throws everything off. By the way, in our culture, hurrying up and doing stuff you didn't prepare for is a way to make mistakes. If we make mistakes, we can kill people. We don't like to kill people. We're expected to save the astronauts and bring them home alive. You're asking me to change something—you're asking me to get somebody killed. That's a very the normal way flight directors think. All dots connect back to "Because you're asking me to do this, we're going to fail this crew."

As a lead flight director, it's all an exercise in getting more and more comfortable with those things. Earlier on in my career, I learned how to present challenges to people so that they don't get stuck behind "the impossible." As a lead flight director, much of the experience was trying to apply that same lens to myself. These guys now want me to change this, or they're now telling me my baby's ugly. How do I not respond from that emotion and just listen for the real problem, and how can I satisfy whatever their need is? It might be changing part of the plan. It might be changing it exactly the way they want me to. I might be able to do something else that's not as significant a risk on our side, but still does for them what they need done. Of course, you're juggling all of those thoughts while you're getting closer and closer and closer to this real scary thing that you're going to do that, by the way, your name is all over. When it doesn't go well, everybody legitimately ask, "Who was the lead flight director that planned this?"

You have all of these people pulling on you, wanting changes. Most of the exercise is keeping it together and not losing your cool or your sanity, up until the time you start flying. Once you start flying, things become much simpler again, because all the rest of those folks have to sit and watch as it unfolds. They can't really help you while the clock is ticking or the rocket is spewing fire out. The team has to be able to do it.

My family would tell you that Dad had "flight mode." Most flight directors' families would say this. It isn't a compliment. Sometime within a few weeks of flying a flight or some real operation that I'm going to go on console and lead, someone in my family would say, "He's now in flight mode." They would all then make themselves scarce. My girls, who today are 23 and 26, still tell people, "Oh, yeah, we would watch when he got out of his car and was walking in the house. We could tell just by the way he walked up the driveway, he's in flight mode, let's leave him alone. We would just give him an hour or so of being home before we would start trying to talk to him, or we would let him come to us and start talking to us first."

WRIGHT: Maybe it was flight mode for them. They "flew" to give you that space to do that. It was a very interesting time when the assembly missions started, because so many flight directors were so busy, because you had one for Station, you had one for the Shuttle. Not everybody was trained for both, or maybe the true statement is that not everybody served those. How were those differences made, and was that a choice that you as flight directors made? Or did someone above you make that decision that you're going to take this route and somebody else is taking this route, and you were lucky enough to be able to do both routes? You were both a Station and a Shuttle director.

HILL: Yes, I was definitely lucky, I was in the right place at the right time, considering I hadn't "grown up right." In all seriousness, I never should have been a Shuttle flight director. I was allowed to be one because they really needed one, and I had already done so much of the training. They decided to take a chance, because they didn't have a quicker option. But the intent was to select someone to be either a Shuttle or ISS flight director, then leave them to get certified and finish their time leading operations for that spacecraft.

At the same time, Bob [Robert E.] Castle, a veteran Shuttle flight director, and one of the real heroes of the business, took a great personal interest in Space Station. He was assigned to be the overall lead flight director for Space Station operations and make sure it was all pulled together. By the time we were ready to fly, he was relied on to tell the Chief of the Flight Director Office, "Yes, we are go."

Because of that, Bob got Space Station-certified because he wanted to know it well enough that he could pass judgment. That "broke" the original idea. So, Bob is a Shuttle guy, who then was also Space Station-certified. Then, because the office had a problem, I was a Station guy who was Shuttle-certified, even though that never really was the plan. Then, after a little bit of time, we hired some more Station flight directors. With them on board, Jeff [Jeffrey] Hanley, one of my classmates, was allowed to cross-train and also get Shuttle-certified. In fact, there were some folks back probably about the year 2000 or so that started saying, "Well, Hill has done well on both, Castle did well on both. Everybody can just do both, what's the big deal?" I agree, technically, anyone could fly both Shuttle and Station. What you can't do is be *good* at both at the same time.

When I became a Shuttle flight director, I spent 6 to 12 months almost exclusively doing Shuttle work, in order to, as I said before, have the chops and be able to do it while the clock is

ticking. I had to really focus. I still did some Station stuff, but not nearly as much as I had been. After I'd worked a Shuttle flight or two, and I had a Space Station flight coming up, say within the next 6 to 12 months, then I went hands off on Shuttle, stopped doing any Shuttle sims, stopped working Shuttle flights, focused full-time on just Station, in order to get resharpened on Space Station. I don't think it's possible to stay sharp enough for, no kidding, real-time response and leading the team in real time on two different spacecraft at the same time. You can go back and forth, it's just it takes a few weeks to relearn some stuff that you might have forgotten when you go back the other way. Plus, things change.

I haven't worked Station for the last six months or for the last year, and we've added this new equipment, these flight rules have been changed because we learned these things that we didn't know. You have to get up to speed on all of that stuff, and by the time you get up to speed and you start flying, now Shuttle has moved a little bit, so you start getting rusty on that, and you have to go back and forth. By the end of the Shuttle Program, I would say there was a much larger group—I don't know what the count is anymore, but I bet there was at least half a dozen of us, if not more, that had been certified in both ways, on Shuttle and on Station.

The other interesting thing when you think about stereotypes, or prejudices, that's a better word, it was always taken for granted that a Shuttle flight director, or Shuttle flight controller, could become certified as a Station flight director, but somebody that grew up as a Station flight director couldn't become certified or wasn't sharp enough to get certified as a Shuttle flight director. Even after I had been working as a Shuttle flight director, that was a prevailing prejudice of the Chief of the Flight Director Office. I remember having a few ugly debates about that, saying, "I think you're selling these guys short." If I as a Station flight director could become a Shuttle flight director, having never actually flown Space Station or Shuttle as a flight

controller, then why couldn't our experienced veteran Station flight controllers be certified as a Shuttle guy?

The reason was we had 20 years of prejudice behind us on Shuttle. It's like saying that because we didn't know who John Casani was, he couldn't have been a hero of our business.

WRIGHT: Yes, that constant change of culture, because you had those folks who were Shuttle people, then you had the new Station, and then having to work out—and I don't know what the word is. Is it logistics when you're working those two pieces of you've got a Shuttle mission going and you've got an ISS assembly mission, and so the Station, is that correct, that the Station director takes over during the assembly? How is all that worked out where it's choreographed where everybody knows there's someone in charge, and everyone knows who that is and how that works?

HILL: The first couple or three years, up through STS-104-[ISS Assembly Mission] 7A, the Shuttle flight director was the overall lead during joint operations when Shuttle was docked to Space Station. I can only think of one example when it was invoked in flight, and it was a problem, like the two flight directors weren't getting along, and one of them said, "Tough, I'm in charge, and this is what we're going to do." Not in that language. That was really early on.

Otherwise, it's like the difference between the U.S. and Russian flight directors. As you're flying in space, it's clear, the U.S. team needs to do this, the Russian team needs to do that, *we* are coming up to a decision point—you could almost always get to the right answer without one of you having to remind the other one that *I'm* in charge. I can only think of one or

two occasions where that actually became an issue between the U.S. and the Russian flight directors. One of those two was me.

WRIGHT: Do you want to share details about that?

HILL: Yes, I'll come back to that one. After 7A, the Station flight director was in charge, and that was because the Space Station had become so big and so complex, Shuttle was largely powered down after docking, and it was the Station systems that were generally active. The Station flight director was then in charge, because that's where the center of gravity was for the operation as well as the most active part of the combined spacecraft. Still, it rarely was an issue.

Now, as far as my issue with the Russians, this was way early on in the first year that we were flying the Space Station. The Russian FGB [Functional Cargo Block, *Zarya*] batteries started dying on us. The Russians at the time didn't understand what was causing it, nor did our guys. If they crumped those batteries, the whole Space Station was gone. If we had failed or crashed the Space Station then, there weren't backups. That would have been the end of it, we wouldn't have built out the International Space Station. At the time all we had was the FGB and the node, little bitty can, but it was the foundation.

As the batteries were dying, the FGB electrical system was sort of progressively getting dimmer and dimmer. The FGB had six of these batteries, and they had two fail, which got them down to only four remaining. At that time, the conventional wisdom on the Russian side was they couldn't operate the vehicle with less than four, safely enough for the Shuttle to dock to it to make repairs. We were looking at it like, "Holy cow, if we lose another one, game over."

Because we were in such a critical condition, the Russians planned to test some things with the spacecraft, and the things they were going to test risked causing one or more of the batteries to trip like a circuit breaker. In their own judgment, if another one went offline, the electrical system wasn't adequate, we couldn't continue anyway, so why not test it?

At the time, I was the lead flight director, but I wasn't even in the Control Center. I was at home. I was at home covered in mud, digging post holes, and building a deck. Phone rings, and it's a RIO from the Control Center.

This fellow said, "Yuri Budnik is on the line, and he wants to do a test. He wants to close the switch to a failed battery on the main electrical bus." Budnik was a very senior Russian, great guy and great flight director.

I said, "Did you remind him we had agreed that they aren't going to do that until it's been analyzed and we have data that shows it's not going to trip the entire main bus off?"

He said, "I reminded him. He says *they've* talked about it and *they've* decided it's okay, and *they're* going to do it."

And I said, "Patch me in."

The next thing you know, I'm at home, covered in mud, talking on a Mission Control voice loop to a Russian flight director who's in the Russian control center, who literally is standing next to his electrical guy waiting to tell him, "Send the command now, we're going to do it." Now, thankfully, Yuri showed me the courtesy of not doing it until he told me he was going to, but he wasn't asking permission. He was just telling me, "Here's what we're going to do, we've talked about it." He was expecting me to go, "Ah, oh, okay, ah, tell me how it goes."

Instead, what I reminded him was, "Here's where we are, it's very precarious, we're not in a hurry. I understand why you guys want to test this, but we're not in a hurry to do it, and if

you're wrong, we could lose the entire Station. I can't agree." At the time, our rules put the U.S. flight director in charge. It wasn't one we talked about a lot, because it made the Russians mad. But in fact, that was the agreement.

There was this pause, and Yuri said, "Well, my experts tell me it's okay, so I'm going to do it anyway."

This went back and forth, where finally said to him, "Yuri, I'm telling you now, you're not authorized to take this action." By now, we're both angry, although I'm sure I raised my voice first. We were going through an interpreter throughout. He would yell something in Russian, the interpreter would say it, I would yell back in English, and the interpreter would say it back to him. Although Yuri didn't really need the interpretation, he spoke great English. Much better than my Russian, although I understood some Russian. This went back and forth, with the whole U.S. side in the Control Center listening in.

When it ended, the Russian team did not send the command, and they didn't do it for another three days, until their engineering team did some analysis, showed the analysis to our engineering team, and they all agreed the risk was understood—we're not going to risk losing the whole spacecraft, which we didn't.

To me, the fascinating ending to that story is that you would think, "Wow, I've now just severed my relationship with the Russians." Going back to that cultural class, and how many Americans, in my opinion, misused or misunderstood the information. Most of my American friends or colleagues who engaged a lot with the Russians were mad at me after that, because it was assumed I'd now ruined the relationship. I'm thinking, "You know, guys, my focus was saving the spaceship. I really did think that it was more important to do that than to get

Christmas cards from Yuri Budnik.” Many were furious with me anyway, “Oh, I can’t believe you talked to him that way,”

I said, “Really? Did you listen to the conversation? Because I’ve got a recording of it. Did you listen to him tell me he didn’t care what I thought, and he was going to do whatever he wanted with the *international* asset that we *can’t* replace? And you’re putting this on *me*?”

This went on for a couple of weeks. Next thing you know, I was asked to take some engineers to Moscow to sit down with Yuri Budnik and some engineers from the Russian side to analyze their electrical problem and see if we could come up with a joint solution, so that we don’t keep failing the batteries. In fact, what I was asked to do was go figure out how we’re going to fly this thing if we lose one more battery, because if we get down to three, we can’t just give up. Figure out how we’re going to do it, because we’ve got to get the Shuttle up there. If nothing else, we’ve got to get the Shuttle up there with more batteries, so we can fix the darn FGB so that we’re not one failure away from losing it.

I show up, and here’s Paul Hill, enemy of the state. We sit in this conference room, probably not much bigger than this room. Americans on one side of the table, other side of the table filled with Russians, actually most of the room filled with Russians, which is really different, in our experience. In our experience, usually it’s lots of Americans and a handful of Russian experts. This case, it was half a dozen Americans and a roomful of Russian guys, all experts on different parts of their spacecraft, and Yuri Budnik, who was the flight director in charge of everybody.

Actually, there was only one guy senior to Yuri in the whole operation, Yuri Kolchin, and he came in from time to time. We were there for five days, and the discussions started off very tense. I would ask questions, and I would get the “Why do you need to know that, we’re looking

at it,” kind of response. The Russians would all talk amongst themselves in Russian, frequently complaining about me. Interestingly enough, not unlike some of my American experience, complaining about how arrogant I was, and how I hadn’t grown up right. Who did I think I was asking them these questions?

By the end of the week, Yuri Budnik was either sitting next to me or leaning over my shoulder while I typed on laptop computer. We were going line by line in a spreadsheet saying, “I think we can turn on this piece of equipment, and I think we can turn this one off.” You’ve seen the movie *Apollo 13*?

WRIGHT: Yes.

HILL: The exercise they go through in the simulator, trying to stay under a certain amount of battery amps? We did that exact exercise on paper, component by component, amp by amp. The Russians had assumed that they couldn’t fly the FGB safely on three batteries. We figured out how to do it on *one*. As we were doing it, we would occasionally (rarely) get to some piece of equipment, and Yuri would say, “Oh, I don’t know.” He and I, with the help of a couple of the American smart guys and some Russian smart guys, we’d think, well, we could always do that one differently. How about if we did it like this? We’re talking about operating Russian systems that we only have so much of an understanding for, but it does the same function that a U.S. system does. We’d dream up, well, if we operated it differently, we could actually use less power, or we could turn this thing off over here temporarily while we turn this thing on, and when we’re finished with this thing, we’ll turn this one back on, because this thing over here has to be on anyway.

As we would progressed, Yuri would say, “I think that would work.” Or he’d come up with a different, crazy idea to solve the same challenge that he did believe would work. He would lean over to some Russian, ask the Russian questions, they would all start yelling at each other, arguing about it. At the end, he would look at me and say, “They agree. We can do that.”

At the end of the week, the Russian chief designer, he walks in. He’s a stereotypical Russian bigwig, big burly, no-nonsense guy. He sits down and starts talking in Russian. This guy is large and in charge. Everybody in the room except for Budnik appears terrified of this him. As we’re explaining our final conclusions that enable us to fly the FGB at such low power levels, he starts asking questions. “Well, why did you do it this way? We’ve never done it this way before.” The Russians are all speaking in Russian, but the interpreter is not translating most of it, only the occasional significant point. But it was clear the Chief Designer was not happy.

As they were talking, the interpreter keeps looking back and forth from them to me. They’re yelling back and forth amongst themselves. As the Chief Designer would challenge a Russian engineer on some decision, many of their answers would be, “Mr. Hill talked to Mr. Budnik about that, and Mr. Hill decided this was the right way to do it, and we agree.” One thing after another, they kept coming back and saying, “Well, Mr. Hill—Gospodin Hill—says.”

The interpreter leans over, and says, “The Chief Engineer just asked them, ‘Whose spacecraft is this, mine or Mr. Hill’s?’” The interpreter points over to one of the senior guys was across the table from me and said, “And that guy just said, ‘It’s Mr. Hill’s.’”

Hearing that was actually one of my proudest moments. This Russian interpreter was just beaming. I wished the rest of the American community could understand the underlying message of that moment. As opposed to being afraid that these guys aren’t going to like us, just engage with them as peers, engage with them to do the right thing, stop trying to be pals with them.

Why do you think that they don't respect us and they try to run roughshod on us? Because so many of us are trying to be pals with them rather than negotiating and holding the hard line on things that matter.

Besides that, it definitely felt good personally to hear that. From that moment on, Yuri Budnik and I were very good friends, with great mutual trust. We went on to work together many times in the Control Room. In fact, when we rebuilt the FGB electrical system on the next Shuttle flight, there were problems getting the new batteries installed and activated. The problems started when I wasn't on console. I came in in the middle of the night, plugged in as my team was coming on, and I called Yuri in the Russian control room. The first thing he said on the loop was "Paul Hill, it is good to hear your voice. Now maybe we can figure this out." I just got a chill, just thinking of it. To hear Yuri Budnik say that to me while we were flying, and to ask for and accept suggestions from me on what they should do with their spacecraft when it mattered most—it meant the world to me.

Thankfully, we were right in all of our calculations and crazy schemes. The FGB and ISS were safe. As usual, it looked easy, and most people, even in the space business, never really knew the story.

WRIGHT: It certainly set that mode of we have reached the international connection as it was meant to be.

HILL: It was great for me that, "Wow, they care what I think." The bigger thing for me was Yuri Budnik, somebody who I now look up to as much as I do and a hero of the business that few will

ever know of, but that guy was tremendous. To know that *that guy* thought that *I* made that kind of a difference. Oh, gosh.

WRIGHT: The level of respect is amazing. That's terrific. It might be just—I can't think of a better way to end today's session, except with a story like that. We can stop for now. We can pick up on Thursday, and see what else you did while you were there.

HILL: Okay.

WRIGHT: Thank you.

[End of interview]