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LISA M. REED
INTERVIEWED BY JENNIFER ROSS-NAZZAL
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ROSS-NAZZAL: Today is July 24th, 2015. This interview with Lisa Reed is being conducted in Houston, Texas, for the JSC Oral History Project. The interviewer is Jennifer Ross-Nazzal, assisted by Sandra Johnson. Thanks again for driving down here to spend some time with us today.

REED: My pleasure.

ROSS-NAZZAL: Really appreciate it. Last time, we had a great conversation. One of the things we didn't talk too much about, though, were the tools that you used, the simulators themselves or the trainers. I noticed, according to your resume, that you developed simulator model requirements. Can you talk about that and what that involved?

REED: Yes. Every instructor that worked in the simulator at some point would come across a need to write requirements for the simulator. If you think about the simulator being a machine that is run by computer programs or models—if you got a new system that was going to be put into the Shuttle, that model would now be obsolete until you wrote the requirements to tell the programmers how to program it to make it work. I'm not talking about telling them how to code.

For example, we got the [the Androgynous Peripheral] docking system. We had not had that docking system [model in the simulator] before. It came from Russia. We needed to create

a docking model in the simulator in order for us to do these docking simulations for Shuttle–Mir and then later for Space Station. [I] worked together with the MMACS [Maintenance, Mechanical, Arm, and Crew Systems] flight controllers, because they were the operations engineers, and others in my group to determine what did we need to train, because you really train from what you have in the procedures. What were the [docking] procedures? That started way back with learning about the system and flying down to the Cape [Canaveral, Florida] and actually seeing the docking system before it was put in the vehicle, and going out to Rockwell, [in] Downey [California].

When they [Rockwell in Downey] got a test unit out there, of the docking system, we sat, and basically—I'm going to use the term loosely—played with the system to see how it operated. We would activate sensors and see what it did [how the system reacted]. We would activate it, and watch the docking ring go in and out. You go and you learn about all this first, and then, from that, the fight controllers would write the procedures, determine what the crew display needed to look like, and then we [the instructors] would get involved because now the simulator had to be programmed to be able to do that [simulate how the docking system works]. I wrote requirements along with others for the various systems, [and] wrote those for the docking system.

What came along with the docking system was this airlock. It [the docking system] sat on top of the little airlock right outside the hatch of the Shuttle. The crews were going to need to be able to practice venting that airlock and bringing it to the vacuum of space if they were going out to do a spacewalk. Or if they docked [to the Mir], the hatch was up above in that airlock—the external airlock—and that's where the folks [astronauts and cosmonauts] would be coming over from Mir when you opened the hatch and saw all of the handshakes, and later on Space

Station, every time you saw a crew dock and greet the Space Station crews [until the Space Station airlock was installed on the Space Station]. All of that [those models] had to be programmed. When I refer to writing requirements for the simulator, I was writing those requirements whenever they came up.

Then sometimes the [Shuttle system] model was already there [installed in simulator computers]. It wasn't a new system, but you would, usually through actual flight experience, learn that the parameters or the numbers that were [modelled and] showing on the [CRT or Instructor Station] screen were not quite [exactly] what they were in real life [during a real Shuttle mission]. We would write a new requirement and submit it to the programmers, then they would figure out how to do all of the code, how to make that happen, but we would tell them what we wanted it to do. That's what we did.

Then for every Shuttle mission, they had a generic set of Shuttle [simulator computer] models. They used flight software from the GPCs [General Purpose Computers] that interacted with that [those computer models], so if the mission had a particular payload on it, the payloads guys would have to write the requirements for the flight-specific training software that would go in that simulator [model] for each mission, or if it was an [ISS] assembly flight, or deploying a satellite, all those kind of things. That's why I say just about every instructor at some point in their career had to write some requirements.

ROSS-NAZZAL: Were there periods when the simulators were down? The Orbiter did change over time. There were those Orbiter Maintenance Down Periods out of Palmdale [California], and then they moved them to KSC [Kennedy Space Center, Florida]. Were there lag times in between, when the simulator didn't actually reflect what changes had happened? Like [Space

Shuttle] *Discovery* might get something, but [Space Shuttle] *Atlantis* was behind. How did those affect your simulations?

REED: That's a very good question. They did. This is like a three-part answer. In general, the Shuttle Mission Simulator [SMS] had the basic [Orbiter system] models down [programmed] for every Orbiter. Like you said, there were some idiosyncrasies between the Orbiters. Little things, for example, toward the end of the program, [Space Shuttle] *Columbia* did not have that external airlock because it was never planned to go to Space Station, or never planned to dock to Shuttle–Mir. It was a little bit heavier because of some of the equipment that it had on it. If you were flying on *Columbia*, the [crew station simulator] visuals [simulating the in space view out the Shuttle windows] would not show an external airlock, something you [the astronaut crew] didn't have [on their mission]. When they would deliver that load [simulator computer model software] for *Columbia* mission, they had programmed that [external airlock visual] out of it.

Now, there were times when you did a major [overhaul]. For example, the electronic displays, the glass cockpit, if you will, that came later on in the Shuttle Program—that took down one of the simulators I want to say for, I can't remember, but a long time. It was just out of commission because they were installing those displays in there. We were still flying missions, so we had two others [simulators]—a motion base and a fixed base—that were up and running so that we could maintain the flight training for the crews that were in their training flows.

You had the fixed base and the motion base in Building 5, and then there was always a Guidance and Navigation Simulator—the GNS—that resided in Building 35, right across the street from Building 5. When they would take one of the things [simulators] out of commission.

They took that one down, put the glass cockpit displays in there, and when it came back up, then they took down the other and put the displays in there. We always had the capability to train on whichever configuration until the whole fleet was transitioned over to the glass cockpit. Usually for just the small little tweaks or the little idiosyncrasies between the vehicles, they would do that in the programming of the actual mission load—the flight-specific software loading—so you didn't have to do major things and take the simulators down.

ROSS-NAZZAL: I was curious about that. Did you work at all in Building 9? I noticed that you mentioned Building 5 and the other one [Building 35].

REED: Most times the simulator instructors did not train in Building 9 in the mockups. We might be asked to go over by what they call crew systems instructors—they worked with all the flight crew equipment, habitation, how to use the toilet, how to work with the lockers and your stowage—they would set it up and train them on that.

When I did teach classes later—and this was a little bit of an anomaly [from the normal training process]—when they added that external airlock that went with the docking system, I went over there with them to provide training on the air ducts that went between the airlock. There was a lot of different configurations you had to do of pressure valves and equalization valves, as well as a booster fan that resided in the floor of the airlock. It was this little fan that would boost air—if you imagine your air duct in your house—it would boost the air through that airlock and down into the Spacelab or the SPACEHAB. Or, if you needed to push that through the airlock and make sure you didn't have carbon dioxide from when the crew members would be breathing out and not being able to clear that out of there. [During a real mission], we could

get it [the airlock] closed up, and then all of the sudden you could have people getting headaches [due to high carbon dioxide levels] and not having a good amount of oxygen in there to breathe, so that fan was in there for that reason.

We developed a whole class that taught just how to deal with this new external airlock and its ductwork, its valves, its hatches. I taught that in conjunction with the crew systems instructors in those mockups. Then usually after that, when the crew would go down to the Cape, I was down there oftentimes to go in there and teach them about the docking system [and external airlock]. It was our [training instructor and mission crew] first time to really see it, when they would do their crew equipment interface test, where they could actually see the real docking system, open the actual airlock, and go in there and walk through the procedures and explain where everything was and what they were going to be doing.

ROSS-NAZZAL: That was an unusual system for you to learn, I imagine.

REED: It was unusual, and it was very tight quarters because it was only just a little bit bigger than the circumference of this table. Probably another 12 inches all the way around. You would have three, four crew members in there with you. You would all be sitting on the floor with your knees [pulled] up, pointing to things. In microgravity, they could consume the whole volume, but when we were in the OPF [Orbiter Processing Facility] down at KSC, you just had to squat down and everybody try to fit in there for the class.

ROSS-NAZZAL: I wondered if you would talk about starting to work with mission commanders, flight directors, and mission directors on a mission. Coming up with a flight crew training plan,

what did that involve, and how did those shift or change as a result of what was going on with the program?

REED: Obviously the Shuttle Program Office would set a flight manifest. They had the objectives of the flight, and what was going to be conducted, whether it was going to be deploying a satellite, was it a science mission like a Spacelab, or later on in the program was it going to be an ISS [International Space Station] assembly mission? Rendezvous and dock? Whatever. Hubble rescue [retrieve] or Hubble repair. Those sorts of things. Those initial requirements get set by the program, and they would come down probably about a year or two before [the mission flew]. You'd know that those flights were in the offing.

As they got closer to flight, you [the training team] were usually assigned. You knew what your next mission was going to be. As a trainer you were waiting for the crew assignment, but you might have line of sight as to, "Oh, this is going to be a fun flight" from what they were doing [on the mission] perspective or what the objectives of the mission were. You may go to meetings and learn about it, usually before the full crew was set. You might have an idea, because you'd see the CB [Astronaut Office] rep for that flight in those meetings, and you'd go, "I wonder if that person is going to be one of the crew members?" More often than not, they were. They were assigned eventually.

As far as the training requirements, the training division set basic requirements for all Shuttle crews based on their [experience]. Some of them had to take everything in a training flow, once they were a mission crew. Others were designated other requirements that they needed to take, by their position, their role: commander, pilot, mission specialist, payload commander, or EVA [Extravehicular Activity]-1, EVA-2. Those requirements were known

already and determined by the training division, just over experience and long time [training these missions]. There was a basic training flow.

Once you, as a team lead, were assigned a crew, you met with the commander; typically first, you would sit down [together with commander]. Because the commander was allowed to make crew assignments, who was going to be what [position], you'd go up and then a commander would say, "Okay, here's what I'm thinking." For example, with Eileen [M. Collins], obviously the pilot was going to be the pilot, and she was going to be the commander. So whoever was pilot, you knew who that was. That was set. She said, "I think that Dr. Stevie [Steven A. Hawley] is going to be the flight engineer, the MS [Mission Specialist]-2, but he's also going to be key for the Chandra [deploy]. Then she would go through and assign other little tasks. We had a whole list. Who's going to take the photos of the ET [External Tank] when you separate? They always try to capture those pictures and review them. Who was going to be responsible for going downstairs and helping the crew de-suit [after they were on-orbit] and in what order? You'd get a rough idea. It was all thought out. "I think I'm going to have Cady [Catherine Coleman] doing this. I think I'm going to have," so on, so forth.

There was generally that idea, when the commander had an idea of what they wanted everybody to do. Once you knew that, you could go back to your training team, let them know. It was all in a little list, a matrix. You could see who was doing what, and you would begin to train. That was just for the generic, upfront training to get ready for their mission. They would start through a series of SSTs [Single System Trainers], refresher courses.

You would then begin to do some initial training in the simulator. You might not have your flight-specific simulator models yet, because they [the programmers] might still be working on it. They called it your SMS load. It was the software load for that [mission]. So you would

do some generic training with them upfront. Just get them all together as a crew, fly some ascents, do some orbit stuff. They began to learn how each other works. Because while they've all been trained, people are different, so that's a good time for them to begin to understand how each other works. Eileen, or Jim [James D.] Wetherbee, if he was the commander, began to lay out how they want things to go. You usually had rookies and experienced people, so the rookies were always very eager and wanting to do just anything they could. There was a lot of teaching of them, not only by the trainers, but by the flown crew members who were with them.

Just before you began to get into the flight-specific training, which meant you would be doing integrated simulations with the Mission Control Center [MCC], you would already have an idea. At the same time, they could see who was assigned in the training division to work this mission, and you could see who was assigned as the crew. You would know who was the flight director, the lead, the ascent/entry [flight directors]. You'd learn who your CapCom [Capsule Communicator] was, who the Flight Activities Officer was, because they were going to be responsible for putting out that flight data file and the flight plans that you were going to be training from. You began to meet people along the way, and you knew who was working it [the mission].

It was not uncommon for the Sim Sup [Simulation Supervisor]—who led the team of instructors that were more senior, that sat in the simulation control area, monitored, and were responsible for putting together the scenarios to train the mission controllers along with the crew—it was not uncommon to sit down with them and the flight director at some point in time. They would begin to ask, "You've been training your crew for a little while now," and just ask what were things that we thought we needed to work on, or what did we feel was important to

exercise [the crew on with respect to mission activities]. That was really all it was, because then they were responsible for setting the [simulation] scripts.

Early on, we, the SMS team, developed all the scenarios that the crews would train on, and we would train them on all their specific mission stuff. An example of [STS]-93, the major objective was the Chandra Observatory deploy. We had classes that taught them how to: leading up to the deploy, deploying it, post-deploy. You had the initial normal deploy, get it out there, and then after that you start breaking things and getting them used to working the malfunction procedures without anybody else in the sim. It's just a stand-alone sim. It's just the crew and the instructors, to prepare them for any eventuality, but they haven't worked with their MCC counterparts, or the team that will be on the ground with them, who they'll be relying on, on the actual day. That's how that went.

There was a training flow, but there were always discussions. As you go along, you think, "wait," or you learn things as well. Some things may change about the flight, maybe the launch window changes. Well that changes some of the parameters, if you slip. We slipped a lot on 93. Not necessarily due to 93, but other events just caused us to slip. Every time that would happen, the crew would see a little bit different ascent. Maybe it went from a daytime launch to a nighttime launch, or an early morning launch to a dark launch, because it was even earlier morning, and it was still really, really dark. All of those things, you wanted them to be trained on. That's the little tweaks that you would have, and that's why you might have conversations, not only within your own team, but with the flight director and others, and the commander.

ROSS-NAZZAL: I was curious about that, because I was thinking sometimes they might add an EVA or a new payload, what have you.

REED: Yes, we would have to shuffle to accommodate. Sometimes we had to do those pretty quickly. If it was nearing the end of the training timeframe, you'd have to go, "Oh, this changed." It may be a very good reason. I think that's one of the reasons that most of the instructors and the flight controllers that I know, just by our nature—you may not like change, but change does not ruffle us too much. If something happens, it's like, "Okay, well what's the re-plan?" You're just thinking that in your mind. You learn, because every day was something different. Launch slips happened, and launch scrubs happened. You might have sent them down there for a launch, and maybe they get down there, and a vehicle problem happens. They scrub, and it's two months. Well, you thought you were done training that crew and would go on to the next one; they would be back, because you didn't stop training if they came back. They had to maintain their proficiency. You just had to be flexible with whatever happened.

ROSS-NAZZAL: Roll with the punches, as they say.

REED: Exactly, roll with the punches.

ROSS-NAZZAL: So many of the Shuttle flights had industry. Later on, there were a lot more international partners flying. Then there were also DoD [Department of Defense] flights. Can you talk about the different challenges each one of those kinds of missions would pose?

REED: At the time, I did not work any of the DoD flights, because they actually ended before I actually got into the SMS as a certified instructor, but we did have DoD partners that had experiments. I can talk about the industry and the international partners. Let me think.

On STS-93, the Chandra X-ray Observatory, if you can imagine, this observatory had scientists that had been working on it most of their [adult] life. A lot of them had spent their career working on this observatory. They were waiting to have it be assigned a flight. So 93 comes along, and they're very excited about it. They were all over the country. There were some that were resident at Marshall [Space Flight Center, Huntsville, Alabama]. There were some that were up at a center in Goddard [Space Flight Center, Greenbelt, Maryland], so there was a Goddard component to the folks. They were going to be the ones—and I think they're still the ones that—or it might be in Boston. Anyway, they were back east somewhere, and they were going to be the ones actually sitting in the control room, who still monitor it to this day. They still send back those wonderful pictures, all these years later, that monitor what's going on with Chandra, with Hubble, with all that.

You would have the scientists who understood how it worked, and you would have to deal with them coming in [for training and simulations with the crew]. We tried to welcome them, because number one, this is somebody's life work. You can tell by the minute they walk in the door, it's their baby. We all had our particular babies that we were keen on. Also, these were the people who were going to be able to talk to the crew about how this thing worked the best, if you think about it.

Then you would have the Air Force folks. In this case, we had a couple of Air Force experiments, if you will, on 93. They were testing out different materials that they were developing that were flexible materials but super strong and lightweight. There was an

experiment there that they flew, HDTV [High Definition Television] way back when. We had an experiment on there—so this was industry, if you will—that was bringing in a high definition television camera, which by the way was about the size of a suitcase, a big one. I shouldn't say that, but it was large. It was like one of the video cameras you saw back in the '80s. It was large, a little bit larger than that. Luckily, it was microgravity when the crew was having to handle it. They learned how to use that and wanted the crew to capture some high definition television shots from the mission. It was an experiment, because this was already in development, and here we sit, 16 years later, and HD is everywhere out there. They're broadcasting in HD. Well a lot of this started with some of those early experiments, before it came out.

I do remember when the crew came back, but they had to be trained on this by the folks that were working with the camera. The crew came back, and we saw they were playing some of the actual footage from the HD camera of the mission and of the deploy that we saw. I have to tell you, none of us had ever seen it before. We're used to it now, but it was like, "Wow!" The women, of course, were going, "Hmm. This is a little bit too good on the pores of the face and the wrinkles. Hollywood may not like this." But the definition, you really could see. That was an example.

The Chandra had an Air Force booster, an inertial upper stage [IUS], which was a booster that would fire after we deployed it. That was a DoD piece of equipment. We went down for briefings and training with the crew down to Cape Canaveral Air Station and got briefings on the IUS and how that worked. In the event the crew needed to go out and do an EVA on this, because the deploy failed for some reason, we always had a contingency. You know, Cady and Michel [Tognini] going to go out, and what pieces could they detach to send it on its way?

With the international partners, first experience would have been with Shuttle–Mir. That was predominantly just learning—I think, for me—the docking system. It was a Russian docking system. We had to write those requirements that I was telling you about for the trainers, and we had to develop a whole training flow to teach people on our side the docking system. That required us having to work a lot with some of the Russian engineers to just understand how it worked. I remember some of our engineers bringing out the Russian drawings, and that's when we discovered how their system was so very sophisticated. It was simply elegant in how it was wired and still achieved the same outcome of having some redundancy. Whereas the Americans, same way, but just different. They each result in having that redundancy that you need in space in case; a single point failure, that's a bad thing.

It was funny, we always had maybe one, two, three failures deep. We would have, for example, in electrical things, certain ways that we would ground the system, so you didn't have shorts that could happen and tried to avoid them. They still happened, but you'd try your best to engineer that out. The Russians just did it totally different. We began to discover wow, that works. It's just a totally different way of looking at things. When we began to talk to them and also train them on it. It was the same thing when we were training the cosmonauts. You would see, for example, pressure drops. If you had a leak in the cabin, it's a bad thing when you're on orbit. You're losing your air. How you go about doing things. They use millimeters of mercury. We use pressure per square inch, absolute. So training the difference, but they all worked. When we docked with Shuttle–Mir, those would be in millimeters of mercury. Their gauges and things like that, and ours would be in pressure. It would be a pressure gauge. You had to learn to translate things back and forth.

We had to write procedures. We called them the joint procedures for these Shuttle–Mir

missions any time we were either going to approach and dock, so rendezvous in proximity operations to the Mir. Docking. Joint ops, that's when we've docked. Everybody shakes hands, and now we're open. The two vehicles are connected as one; the airlocks are open. They're doing whatever their experiments and missions were. You had to have procedures for that. So half of the books had to be written in English, and you'd flip them over, and there's a Russian version for the Russians. So there's a little more work to do there. The way it was written later, I think, in Station, you had similar types of things. If it was a Russian module, Russian-built module, then it would be in Russian and they would work it. The American's module would be in [English].

All the crew members had their native English and would learn Russian; the Russians had their native Russian and would learn English. They trained for a long time having their languages so that they could read those back and forth. The international astronauts from other countries had to learn both. A lot of them came either already knowing English or they may have already flown on the Mir Space Station. For example, Michel Tognini had flown on that. Some of them had already had experiences flying on the Russian craft. That was just a natural thing. A lot of the international partnership thing, from the instructor's perspective, was just making sure that the crew members that came in that were international astronauts—I would try to counsel them, especially the American crew members, if you're talking, they may not know when you're saying, "Hey, let's go around the horn," what that means.

ROSS-NAZZAL: What does that mean?

REED: Everybody gets to have a say during the debrief. That was just a common phrase some of them would use in the cockpit up there. "OK, let's go around the horn. Jeff, you got anything?" Trying to think of others. We'd try to especially caution them. We use a lot of slang, and in their language, I'm sure they do too, but you have to be very careful to at least explain to them what you mean before you use it. That's very important to that whole crew resource management, which is how a crew is working together so that everyone has the situational awareness of what's going on and knows the role they need to play and things like that.

ROSS-NAZZAL: I imagine it was interesting working with all these different groups, because obviously, you saw a different culture with the Russians and the international partners. Also having these Air Force people come, and then also these highly regarded scientists who have been working on this one piece of hardware for so long.

REED: For me, I just remember respecting, because at that time, I was like, I can't imagine working my whole life on something like Chandra or Hubble. Before it ever got to fly, and the world ever got to see how beautiful it was. Having the passion to stick with it, and not knowing when, if any time, it was going to get on to some launch vehicle, whether it was a Shuttle or one of the expendable rockets that was launched. I just thought, "Wow, that's dedication." Wanting to stick with it for your whole career.

Then I also, because I'm a little bit of a feeler, I could think how cool it was to finally get to this point, now you're going to see this thing get launched into space. That's really what you're waiting for. See what it's going to return back to you. That's cool. I still am on the lists—the payload flight controller, he still stays in touch with those guys, and he'll say, "Oh,

here's some new stuff from Chandra that got released today." Then I'll be sitting at my desk, here in Houston even today, and an email will pop in, and I open it up, and go, "Wow, that's really cool!" It's still out there.

ROSS-NAZZAL: I'll have to go out there and look. Hubble gets all the attention.

REED: Yes. It's funny, I walked in to a conference room where I work now, which is in the energy industry on the other side of Houston. Hanging on the walls is just some beautiful pictures from Hubble that they've had that they thought were cool to hang in this conference room. One of the guys was sitting there, and I said, "Oh wow. Horsehead Nebula." And he goes, "You know what that is?" I'm like, "Yes I do." He says, "It's so cool, isn't it?" I said, "It is." I still see these little bits, even though I'm not actively working in the space program. That's the reach that it had, I think. Everywhere I go, I still run into things like that.

ROSS-NAZZAL: You had worked Shuttle training for so long, but towards the end of your time here, we started with the International Space Station. I was wondering, how did things start to change in the training world now that we're moving to a fully crewed Station?

REED: How things changed. They changed a lot. I'll try to be clear. Prior to Space Station flights and the construction of the Space Station, Shuttle did some sort of deployment mission, and/or they did payload missions and science missions, not to say that any of those were simple. But they weren't—let's say if—and this is for example, because I'm not saying it happened—but there was some reason to slip a Spacelab flight, and the crew would be training in Marshall, and

they would be training with Spacelab people, and that was the payload. They sat in there, and there were all these doctors and scientists that had experiments that they were also waiting fly on the Spacelab and see how things turned out. Let's say that mission was going to go in May of a year, and it ended up slipping; it was indefinite. It was not going to impact either mission in front of it or behind it because they were independent missions.

When Station came along, they were simply build flights. It had already been planned how the Station would be assembled, piece by piece. If a Station assembly flight on a Shuttle, maybe the hardware wasn't ready, the piece that they were supposed to take up, or the Russian side slipped, you couldn't leapfrog over one to the other, because each mission was assigned that next piece. It became a little more difficult for the program when there were flight slips. All it did was just compress the timeline that they had. It would affect every mission after it. Does that make sense? You needed to take up the truss, the zero truss, and anybody that had the next trusses to go up couldn't go up until you got that truss up there. That was one of the biggest things I saw as an effect to that.

It affected how you trained, and in some cases, it compressed some of the timelines for the training. Maybe that thing that you were taking up for Space Station did slip, but it wasn't such a long slip, maybe it was a month or so. There still is crew next to you training that's on the next flight. It compressed your time to be able to get everything done. When I say "your time," whoever you were supporting that mission. Whether it's a trainer, a crew, the people having to get the procedures ready, the mission controllers, and being able to get all of their required training in, the integrated sims in if the stuff was down at KSC in the Space Station processing facility. In other words, everybody's timeline might get a little slip, but you still try to make it,

because you really didn't want to slip that next flight if you didn't have to, because it's just a domino effect. That was the biggest thing.

I think that the second way that I saw it change, that impacted us [the instructors] directly, was that they built a Space Station simulator. That was fine. It was right next to ours in another part of the same building, in Building 5. In the past where we would do testing on all of that software, when we would do the requirements, we'd get our load and we'd have to make sure our training load worked for a Shuttle mission. Well, we now were integrating with a new simulator for the parts where they docked and were going to do whatever—attach that air lock, or that truss, or go out and service some equipment—whatever it was, those on-orbit pieces, we now needed to train with these two simulators.

Initially, in the first few flights, the simulators didn't play well together, for lack of a better word, so that became quite a task to get them to work. We would test them together, for example, bringing the two ECLSS (environmental control environments, Environment, Control and Life Support Systems) together oftentimes was a thing that would just kind of take them both down. It just wasn't working. It was probably a few years before that got where it worked a lot better.

Each time, I would just remember that the two teams—because there would be a training team in the Station, and a training lead in the Station simulator, and you'd be working with them on headsets, before you ever got Mission Control involved. We had one simulator and one Mission Control room. When we had the ISS, if it was orbit, we had two simulators that had to connect and play well, and then we had two Mission Control rooms, a Station control room so it just got more complicated in that respect. It took a few years, but eventually it got ironed out, and things got smoother, but there was a lot of learning. A lot of late nights, a lot of what we

called anomaly reports on the simulator: This doesn't work; you got to get it fixed. We'd be writing ARs [Anomaly Reports] all the time, and the poor software guys were trying to noodle on these things. How can we fix it and work together? Because it was two separate sets of programmers that programmed each one. That's how our world changed. For all of us, and not just us; it was the Station guys as well.

The third biggest thing I would say as a trainer that impacted us when Station assembly flights came along is, in the past, those crew assignments that you had. The smallest crew I was ever assigned was the crew of STS-93, so it was five people total. Between those five people, they had distinct tasks, and you usually didn't have as full a flight with activities as you got with the Station assembly flights.

Let me explain. Chandra, the main objective was deploy the Chandra X-ray Observatory. That was the big thing. There are always lots of little experiments or tests that they may be doing, but none of them require flight critical, on-orbit type training. You don't have them all stacked together like rendezvous proximity operations. Every Station mission was going to have that as a given, because you're docking and building on. That's a very critical operation. Every rendezvous and docking would also have maybe two, three, four EVAs on them, that's a whole lot of training for the crew members that going to be doing those EVAs as well. There was an element of resupply obviously needed once we had crews living on Station, so you might be taking up a multipurpose logistics module (MPLM) full of stuff that you were trying to stock the Station with, and then stuff to bring back that they didn't need anymore.

All of that took extra training, if you had it all added to one flight. The Station flights became more loaded with a lot of very critical and normally high task, and therefore high training requirement activities. The flight plans got a little fuller, but the training plans also got a

little bit fuller. At that time, they separated [kept the ISS crews and Shuttle crews training flows separate].

Let me back up. There were two ways that you could get crew members to the Space Station. They could go up on the Space Shuttle, or they could go up on the Soyuz. For those that went up on the Soyuz, all of the crews—the Space Station crews—spent [an] amount of time training in America, and an amount of time training in Russia, and that was worked with a set of training managers there and in Russia that determined what that would be. It might be a two-year training flow or a year-and-a-half training flow. You're going to be in Russia here [during a certain timeframe], you're going to be there, and then you're going to fly back this time—the last-minute details of working with the Shuttle crew you're going to go up with. Then you launch.

At first, there was not a whole lot of interaction between those [ISS] crews [launching to ISS on a Space Shuttle]. It was almost as if they were flying up on a Shuttle, they were passengers. They weren't assigned any Shuttle tasks, in other words. If you think about having all of these Shuttle missions, which now have a rendezvous, proximity operations, a docking, four EVAs sometimes, and then any other experiment, maybe it was IMAX. That requires training and teaching them how to use that. Anytime we teach them how to do something normally, you also have to teach them about the malfunctions in some way, so that adds to the training.

What we were seeing was, you had seven seats in the Space Shuttle, and only four of them were actual Shuttle members of your crew. Because the other three were ISS crew, you couldn't use them, so these four crew members would get really heavily loaded in their training, right? Their hours in training would go up, and that's what I began to see as a concern. Just like

you don't want your airline pilots having long duty days such that they're tired and they don't get enough sleep—it's documented. There's evidence that when people are tired, when they're fatigued, they will make more mistakes. They may not process things as well as they normally do. It was a concern. That was sort of the biggest effect I saw for those missions where it was a Shuttle taking up the ISS crew because that took away, potentially, bodies that you would have assigned to the Shuttle side, that could then be used by that commander to do those things.

I did raise that issue on STS-102. Long story short, I don't think the two programs had been talking [about the unintended consequences caused by keeping the crew training separate for ISS and Shuttle]. It's just like, oh, Station—I don't think they intentionally meant it to be separate, but it just was a lot easier when you're talking about it on paper [in planning that] the Station crews will just be separate, and the Shuttle crews will be separate. Then when we started trying to train those, we realized these people are having long, long days to get in all these requirements, especially EVAs. You can be in that [Neutral Buoyancy Lab] pool sometimes and the way the schedule just worked, they might have them going from your ascent sim into an EVA for eight hours. So we just began to say, this isn't going to work.

They reached sort of a happy medium at some point where they realized—because some of these American crew members that were flying up as part of the Space Station crews were many times flown Shuttle crew members that could maybe not be assigned a major task that would require a lot of training, but they had some previous knowledge, and maybe they could help with some of the photo, TV things. Maybe they could help with the [hand held] laser on rendezvous, and whatever. We left that up to the commanders later to use them [and how they would use them on their flights]. I think it got much better toward the end, but when it first happened, it was one of those things people didn't think about the unintended consequence of,

"Let's just keep them separate and bring them back together a few months before." It put a heavy, very heavy, load on the smaller Shuttle crews as the missions got more complex.

ROSS-NAZZAL: That was the change out from Expedition One to Two? That 102 mission?

REED: Yes. The thing about that is, that particular mission timeline also got crunched for that same reason I was talking about. As things slipped, you still tried to make the dates. It just began to roll down [it snowballed]. So we didn't have quite as long to train STS-102, which was the expedition flight that took them up. My training team trained them. I was seeing the effects of that. The other thing that I also began to experience is as we got to the end of that training flow and they were getting ready to launch, I had already been assigned my next crew for a Space Station assembly mission. We got our next crew, which was unheard of [in the past]. You usually at least got a little—not that you got time off—but you got time off from flight-specific training. We were in the end of our training STS-102, and we had already begun to have early briefings with the STS-110 crew, which was our next crew. They were initial briefings and now moving into the training flow. We were just beginning to see all of that extra work that was coming along with the first crews that were going up on the Shuttle to go to Space Station.

ROSS-NAZZAL: I know we'll get to this later, but I have to ask now, because it's an obvious question to ask. Was this because of the deadline set to complete Station?

REED: I didn't know that at the time. I'll be honest with you, I didn't know that at the time. In our little world—not that we didn't get out and talk to people—when you're training that

simulator and you're focused on that mission, you don't understand why they're saying, "We're not moving the launch date." I have come to learn since then, but yes, that seemed to be what it was. We didn't know all that was going on, because that kind of goes on up at this much higher level [organizational level]. Maybe Congress and other people are involved. It didn't necessarily roll down to us at that time. I just knew that the timeline was tight. Didn't know the reasons why. I was raising it to my management.

When you got within 12 weeks of flight, we were required as team leads to go in and brief status to our management, and there were reps in that meeting from the Astronaut Office; the chief of the Astronaut Office was invited to attend or his or her rep. Everybody could hear, "Okay, here's how the training's going from the team lead's perspective. The Station team lead would do the same thing. You would stand up and brief it, and you did that every week until they flew, so that any issues could be brought up. I do remember bringing that up when I began to see the schedules come out, and I knew that we, as a training team, were simming unbelievable amount of hours. Who are we simming with? We are simming with our crew, but I'm also looking at the other requirements on their time for training in the NBL [Neutral Buoyancy Lab] and training in the mockups in Building 9, or maybe some sort of payload training.

I hadn't seen this in my entire time in the training division with just the Shuttle crew missions. Hadn't put it all together in my head, but I do recall asking my boss—went in and told him, "I don't think this is necessarily safe, or the way we want to do this going forward. I don't know who we have to ask, but is there any way that we can slip mission, even two weeks, just to give these guys a break? Four weeks would be great, but we'll take what we can get." They kicked that off. They got the head of MOD [Mission Operations Directorate] together, and they

got everybody together. How's everybody doing preparing for this mission? Because we were feeling a little crunched. What basically came back, is just about every division in MOD stood up from the flight control world, but whether it was Station or not, and we could use more time. We don't have these things ready. We're really pushing to get them ready for flight. Stuff like that.

I don't remember how it all happened, but I do remember that they then began to—there were training managers, so these were people who put the schedules together for the crews. They began to work together and first thing was they began to use previously flown Shuttle crew members that were going up on a Shuttle flight. They began to use them and work where they could use them. Work with the commanders that were flying the Shuttle for that mission, taking them up, and use them where they could to alleviate a little bit of the pressure. Then these training managers also began to report weekly on the crew loading. How many hours were they [doing] and trying to keep it, if you're judging it by a stoplight—red, yellow, green—trying to keep it in the green. Maybe a little into the yellow sometimes, because that always happened with any flight. There were weeks you just had to train more hours, but you didn't want it to be a consistent thing for months and months on end, because that's just fatiguing and not good practice. It did get better after that, but those first few flights were kind of hairy.

ROSS-NAZZAL: It sounds like it. From what I also read, you were also providing some real-time support for Mission Control occasionally. Can you talk about some of the times you might have been called?

REED: Yes. Well, it's a side benefit or side effect of being an instructor and coming up through the instructor ranks. This was everybody in the training division. You worked so closely with the mission controllers. You learned the systems, because you have to learn the systems to teach the systems, that you can sit in Mission Control with the system you're certified on and you understand the signatures, pretty much, like a flight controller would, but you may not have gone through the flight controller actual certification.

I'm trying to think of when this was. It was probably in the early 2000s. They asked the team leads if we could—I don't recall if it was they were shorthanded, or if it was attrition, or if it was just that we'd had some Shuttle mission controllers go over to the Station side because that was now 24/7/365, right? Either way, they didn't have people to sit in the Mission Evaluation Room [MER], in Building 30, which is a backroom that supports every mission. Has a lot of different folks in there, and one of those positions is the spacecraft analysis (SPAN).

They asked for the missions going forward—I believe the first one I worked was STS-105—if the team leads could come in and do shifts. Because it was basically gathering data from others in the evaluation room, and at periodic intervals, when they would hand over from flight control team from flight control team, reporting out to the flight director. Here's the status and here's what we got. You would get consumables information from the consumables guy. Anybody that was having an issue or anybody who had requested the evaluation room look at something. You might get the stuff passed back to the SPAN room to forward on and report up to the flight director. You would sit for a shift, and talk to people as required. Just like anybody sitting in there, or the flight director, or any flight controller, or anybody in that room could call you and say, "Can you get me this?" or "Can you find out more about this?" or "Can you send me this? Have you got this report yet?" Then if you weren't responsible for the report, which

we usually weren't, we'd call the person that was. "When are you going to have me the report?" That's really what it was.

They knew that the team leads had been [around] enough. Because you do time in your training flow as an instructor. You sit a lot of time in the Mission Control Center learning from those guys from the time you're—I'll call you a baby instructor. Before you get certified, you will sit in the backrooms with everybody that you're learning from. Then you sit—and there's a certain requirement that you do that—then you learn; that's how I learn better, because you can go watch actual mission stuff happening, or during sims, and you can begin to understand how they handle it. You begin to understand why did you see that that was a leak and not just a sensor? They would be able to tell you later. You would learn.

Then by the time you were a team lead, you had a pretty good handle on rounding up people, getting things from them, and disseminating things to higher-ups. That was what the SPAN position was all about in the MER that we did.

ROSS-NAZZAL: Was there ever any time when something happened on orbit that they called you because they were, "We need to figure out something, a solution?"

REED: Yes, that too. The team leads did real-time support in the form of sitting in Mission Control, but every member of a training team, when their crew went into quarantine, was given a beeper, back then. A beeper with your own little number, and your team lead would fill out everybody that got their beeper, and it would be handed to them and you had to wear it on your person or have it near until post-landing. That was in case something happened that they needed you to come in for.

You also had a backup. That was the prime team for that crew. Because you don't know when this is going to happen—it's entirely possible that somebody may be out of range or not able to get back in in time. Because we didn't put them on a requirement, "You have stay in town." Most people did stay in town, but sometimes they were down at the Cape. If it happened right after launch, you couldn't get back, so there was a backup team that also had numbers. You would give the beeper to them, and when the person came back they'd hand it back, but you always had a backup person for each discipline.

I got called in two times for real-time support, and one time it wasn't officially real-time support, but the crew was down getting ready, and it was a docking thing. Something changed with the attitude of the Mir, and we had to go in. We got called in to do some sims and sort things out before the docking the next day.

The two times I got called in, was on STS-60—this was one of those cases where I don't believe they were not able to deploy the Wake Shield Facility as planned. That's one of those cases where it changed the time, and therefore the environment in which they were going to be—maybe the sunlight was now going to be in their eyes, or things like that. We got called in for that. That one was less critical, but more of a function of going into the simulator. Anytime you do that—the crew is usually asleep, and maybe they've, and I'm really having to dig back here—but as I recall, I know they couldn't deploy on the first attempt. Everybody's trying to figure out why can't we deploy this Wake Shield Facility? Pretty much called it a day.

The planning shift comes on, and Mission Control, it was during that time they were trying to look at what had happened. Sort through, do we know why it's not deploying, and what can we try for tomorrow? When they decided they were going to try the next day, that's when they called us in, and they call in astronauts who are also on-call to come over to the simulator.

The flight planners put together the new profile for the deploy and a lot of them usually come over. We all sit in the simulator with the crew members and do the deploy on the ground with the new daylight visuals, or sun position relative to the attitude of the Shuttle. Whatever it was. That's what's sticking in my mind, was they were worried that the crew was going to be doing it in sunlight, and it might be a little bit difficult. Don't quote me on that. Okay, quote me on that, but I might be wrong. I'm old now.

ROSS-NAZZAL: You'll get a chance to review.

REED: I can fill it in later. We went in for that one, and that one was a pretty cut and dried one, because you're going through the procedure and making sure. You're talking back and forth. There's some flight controllers there, payload guys. They're relaying information back to the guys in Mission Control, because they're writing all this [in real time]—what we're finding out. Does anything need to change, because we're going to send the execute package up to the crew when they wake up. That's the whole purpose. We're in there doing all of that. There was nothing anybody saw, so we got called in. We did our job; we went home. It was pretty benign. Didn't see any problems.

The next one was STS-102, and I'll never forget because it was St. Patty's Day. We had gotten back from the Cape. The whole team had gone down to see the crew launch and come back. It was March 17th, St. Patty's Day. It's a Saturday, and we're all just like, "Whew." Okay. Everybody's doing their own thing. My team's scattered to the wind, and it's our first real weekend off from training in a long time. I had gotten invited to the Outpost for a St. Patty's party, and a bunch of friends were going down. I'm like, "Oh great, I'll meet you there." I

hopped in the shower because I'd been doing yard work. I hear this noise. I'm like, "What is this?" The shower's going, and I'm like, "Is my alarm going off?" Then it dawns on me, and I'm like, "Oh, crud. That's the flight beeper."

I get out of the shower. I go, and I call back in. My boss, the team leads's boss—over all the team leads and Sim Sups—it's him on the phone. He says, "Guess what I'm doing?" I said, "Working." He said, "Yes." He goes, "Guess what you're doing?" I said, "Working." He said, "Yes, I need you to round up the team and get to the simulator within an hour." I'm like, "Okay, what happened?" He proceeded to tell me, and then it sort of rolls down. It's a call list. He calls me, and then I got to call my whole team. If they can't make it in, they got to call the guy who's their backup.

The way it turned out is they're on-orbit. They had received a "Freon flow low" message. The EECOM [Environmental, Electrical and Communication] had seen that. Those are not normal. That was a little unusual. Got the EECOM's attention. Freon loops are what help cool and remove the heat [from the Orbiter equipment]. It goes out through the Freon loops and gets radiated and gets out into space. It's the way they shed the heat. Obviously if it's low, it looks like it's getting too cold. Maybe we'll turn on some equipment. When you get on-orbit, a lot of things get powered off you don't need anymore. Some of those are the GPCs. You don't have all of them powered up. The EECOM's solution to turn on some equipment to get more heat was turn on one of the GPCs.

The way it was related to me is there were three switch positions on the GPCs, and there was a certain protocol for how you started them up, going from them being completely off. There was an off position—that's where the switch was—then a standby, and then a run. There was a certain amount of time in the procedure that you needed to wait in standby before you took

it to run. There was some concern—and this wasn't a concern that day—but the way that the procedure was written, there was a concern. Way back when, that if you did that, you could potentially corrupt some of the software by going right through there [immediately from standby to run], potentially. I don't know all of the ins and outs of how it was programmed, but that was the concern, so that's why the procedure was written that you did this pause.

Apparently the crew member did not pause long enough, so this then set off this whole question of, okay, what do we do now? Because those GPCs were not large enough to house all of the software needed for every phase of flight. You would have the pre-launch and ascent software loaded. Then when you got on orbit you would load the orbit stuff, and so on, so forth. What they were concerned about was the entry load. They were in no danger right then and there, but they were very concerned about that [for entry].

We got called in because the Mission Control Center was simultaneously working with their backrooms and other people, trying to find out—this 10-second rule of staying in standby, where did that come from? Was it padded? Some of these procedures were written a long time ago. People were off working on that, but we had to come in then and look at the normal procedure that you would go in to for a failed GPC and redline it for this situation. Again, same thing, my team, we all assembled at the simulator. The astronauts who were here that were on-call for those sorts of things came in, and we began to work through what they called [Failure Recovery Procedure [FRP]-1, which was a DPS [Data Processing System] malfunction procedure. It was about that thick. [Demonstrates] We began to work through that, and it was a recovery type of procedure. Because we weren't sure we even had a failure, there were things that the data processing system instructor on my flight was having to go through.

I remember I had flight controllers on the phone over to MCC [in the simulator]. DPS flight controller who was not on console, standing right next to my DPS instructor. They were both looking at the FRP, and meanwhile the astronauts were out in the simulator working through the procedure and working through the steps. At each step, they go, "Do we really need this step? No. No, we can't do that here." They were literally redlining it [the procedure]. Then she would call it back over to the Mission Control Center. Because we were coming up very quickly on the time when the crew would be awakening, they were hoping to get a reworked procedure up to them [the crew on orbit] in the execute package.

That took hours. It really did. We had a cast of thousands. Then word got out. The potential, if they couldn't figure this out, we might have to to engage the BFS (the backup flight software system), which had never been done. We had it [the BFS]. It was developed by a different vendor than the GPCs [software], for obvious reasons. What if we had some issues with the GPCs [software]? It was developed to fly the Shuttle and work the Shuttle just like the others [GPCs] did, but that way you wouldn't maybe have the single code glitch that might take down everything. This got everybody's attention when even the mention of potentially having to engage the backup flight software system.

One of the big concerns about the backup flight software system being engaged, is you [the commander] had to manually fly [the Shuttle] everything after that [after you engaged the BFS]. There was no automatic [computer flying the Shuttle]. Any flying that needed to be done, the commander was going to have to [manually] fly it. That would have meant, in the entry phase especially, because they do a lot of manual flying on-orbit, but in the entry phase, after you've gone on-orbit for however many days, flying the de-orbit profile to re-enter the Earth's atmosphere. It was not something that anybody would take lightly. People just came [to the

simulator] to watch [what we were doing] because they heard this was happening: the head of the Astronaut Office, the deputy of the Astronaut Office, deputy center director. We had mission controllers from DPS, the flight director who was over the [entry], because the mission management team [MMT] was meeting. Because that's what they do. When something comes up that you don't know how to do, that's the mission management team's job. They were waiting for our input, because that was data to help them make a better decision with all the other data that they had. We were getting called from folks over there [in the MCC]. "Have you got it yet? Have you got it yet?" I'm like, "We're doing the best we can. We know we have to send the execute package up."

Finally we got through it. The chief of the Astronaut Office and the deputy were talking to me, and we went outside because it was just a den of noise. A lot of people talking, and everybody on headsets. That's very uncommon, actually. We walked outside the instructor's station, and at the GNS, you're in the bank of those big mainframe computers that are running that baby, so it's fans and noise, but it was actually not as loud. They were getting ready to go over to sit in the MMT meeting and were just asking me how I thought it went. I said, "Look. If you ask me, this crew—we had a tough training schedule—they've had a tough flight. Not that I distrust any of these crew members—they were well trained—but I think we ought to be very careful about engaging the backup flight system. Right? That would not be my first choice."

They left and went over and were like, "Well, are you going to come watch?" Normally I would have walked over because it's just walking from the simulator over there [to the MCC], but I was so tired. We were just all mentally drained. It was about 10 hours, start to finish. I just sat there, and I'll never forget—Wendy [B.] Lawrence was the Space Station Astronaut Office lead at the time. She was still sitting there. I came back in, and I said, "I'm just going to

sit here and listen to the MMT," because you could call it up on the loop. She's like, "Do you mind if I stay?" I'm like, "No, go ahead." Three of us—I can't remember who the third on was—we all just sat and listened to the meeting. It went round and round, and there was this concern that the entry flight software would be corrupted. Nobody really wanted to do that [engage the BFS], and the flight director running the MMT kept saying, "We're waiting to find out if anybody can tell us why. Number one, if there was this rule of 10 seconds, if it's a hard and fast rule, we just want to understand [why it's 10 seconds]. When you wrote it [into the procedures] was that out of an abundance of caution, or what?" Still couldn't get the answer on that.

Finally this person in the back of the room—and to this is day I still don't know who it was—stood up and said—I knew he was obviously from the software committee. He stood up, and he said, "There's one thing we can try." The flight director zeros in, "Well tell me what it is." I don't remember what it was, but it was one little trick that they could find to do that data dump. See how the 1s and 0s lined up, and it would tell them [give them confidence the software was not corrupt]. By this time, the execute package for the crew had already gone up. They [the MMT] were still working it [the problem]. The package that went up was like, "Good morning *Discovery*," and all of the morning's news and stuff. Then it says, "Today you'll engage the BFS," because that's where they left it [the MMT was still debating when the execute package needed to be uplinked to the crew].

They didn't want to send that redlined procedure. That mega procedure is a malfunction procedure you work all the time. It's a very long one, and nobody wanted to redline it and then have them [the crew] try to go through it. That was risky. They were just going to engage the BFS and test it out. The MMT says, "Okay, well let's try that [the suggested test from the

software person]," and said, "When the crew wakes up we're going to have to call them off of this—what went up about the BFS. And if that works, then we're fine." The crew at least got a little bit of a start.

The pilot, I'll never forget. He told me when he came back and said, "When I read that, I was like, "What?" All in all, whatever little test that guy did—I think it was some software dump or some dump of data—he's obviously very much smarter than me. However those 1s and 0s lined up, we would be able to tell. It would give them enough comfort that the software was working as planned so that they could load the entry software when they got to the time to do that. That one was a little more exciting than the Wake Shield thing.

ROSS-NAZZAL: They didn't end up using the backup flight software?

REED: They didn't. As a matter of fact, right after the crew call—they wake up, and the execute package has gone up, they may very well have printed it out and look at it before the crew actually gives them their morning wakeup call. As soon as MCC started talking to them, they readjusted that, and said, "Okay, things continued, and we're going to do this now. We're not going to engage BFS." Everybody was very happy. We ended the program without engaging the BFS.

ROSS-NAZZAL: I'll have to ask some of those old-timers and MOD if they remember why that rule was that way. I'm sure they won't remember. It was many, many years ago.

REED: To me, that really brought out—number one, how long the program had been going along. It's one of those things—it's why I'm glad you guys are doing this kind of stuff—that somebody probably knew; there was a rationale for it when they wrote it. It may not have ever really been tested that you needed to not do it. It became the norm. Also that rationale, as people moved on, maybe they took that data. It wasn't necessarily written down anywhere as to why, the actual engineering hard data. Why did you say this, then put it in the flight rules, and then put it in the procedures? To this day, in those 10 hours, no one had the answer. Not saying they didn't get it eventually, but it made me think, "Wow, this is a longer program, for example, than Mercury, or Gemini, or Apollo." We're a generation in, almost, and this stuff could get lost as people move away, move on, pass, or change jobs, whatever it is. In the end, it all worked out, and the process worked.

That's why the Mission Control's there. That's why the MMT was there in those cases of stuff that wasn't written down in the flight rules. Occurrences that would happen that were out of that flight rule boundary, and therefore procedural boundary, because the flight rules were established and the procedures were written based on what was in those flight rules to protect the systems [and the crew]. Things are going to come up that nobody planned for, and that was one of those. All in all, the process worked, the Mission Management Team and the Mission Control team working through it. The training team helping out. It all worked.

ROSS-NAZZAL: You were assigned to a couple of other teams over the years, and that was the Crew Procedures Control Board and the Joint Operations Working Group. What were those two groups? What was their task, and what was your role as a trainer?

REED: We'll take the Crew Procedures Control Board [first]. That was affectionately known as the CPCB, because we talk in acronyms. I was the training division rep for a short time. Well, short as in a couple years. The CPCB was there to control changes to the crew procedures. As I was alluding to, the flight rules are developed, and they are the guidelines for each system: each phase of flight, how they expect the flight control team or crew to handle failures, or weather, or anomalies, or various things.

The flight rules, if you ever go pull them, they have different sections. They would have an ascent, orbit, entry section. Then they would have a section by discipline. There would be one for MMACS, EECOM, DPS, GNC [Guidance, Navigation and Control], so on, so forth. In the rules, they've tried to think of the things that may happen and already have a plan of action for how to handle them. If you lose one engine, and you're within these boundaries, you will press to MECO [Main Engine Cutoff]. If you lose two engines and this is happening, contingency abort. If you lose one Freon loop or you have a Freon leak, you're likely going take one rev [revolution around the Earth] and come home. It just laid that out.

If you think about it, it was beautiful in its simplicity. Every time they were on orbit, nobody had to think through all of this if it happened. There was this set of things that were already pre-defined. You trained on those, and the procedures were written for the dynamic phases of flight, especially in the ascent procedures, based on that rule that said if you lose one engine in these boundaries, do this. You lose two engines, do this. This you'll abort RTLS [Return to Launch Site]. This you'll abort TAL [Transatlantic Abort Landing]. It was right there in front of the crews, and they worked it. The mission controllers knew those boundaries. They had it down. They had their procedures. Everybody knew what they were going to be doing if those things happened in those really dynamic phases of flight like launch, ascent, and entry,

coming in on landing. Orbit, you had a little more time, because you weren't sitting on the rocket engines underneath you and going somewhere really, really fast.

That was what the procedures did; you didn't want to change those procedures. Sometimes you had to change them. Usually it came up when you were in training or they were flying a mission, and you realize that didn't really work in this case. Then you could write a proposed change to that. Everyone in MOD had a rep, and they would send out, "Here's a proposed change to a crew procedure, and we will be reviewing all of these"—sometimes it would be a stack of them—"we're going to be reviewing these at the next meeting before we approve them." Nobody could just go in and change procedures, in other words. It was a control board so that every voice was heard, because you may think, "Oh yes, that's fine." The other guy's like, "No, if you change that, then it affects this, this, and this." In worse cases, "If you change that, that is really a bad thing because it might affect the software in this way. It might create this other problem or do damage."

You'd read it beforehand, and you would come with either your yea or your nay, and you would be able to state your case if you didn't want it to change, and why. Then the board would vote on it. Oftentimes as the rep, it might not be in your area of expertise, but you would send it to the people in your division ahead of time. "Okay, I got to go represent this. Give me your feedback." That was the control board for the procedures.

The Joint Ops Working Group really started with the inception of Station. We had done a little bit for Mir flights, but it wasn't a formal group. Anytime you bring two separate vehicles together, two separate crews, and you begin to plan flights, there's other things you have to think of. It's no longer just you and the vehicle that you're flying on and your crew that you're training. That Joint Ops Working Group would get together ahead of time. People would raise

issues, the same thing. "Okay, I see the flight plan is planning for this on this EVA and adding this, we're going to be doing this. This is the best way we think we ought to do it." You'd put it again out to all of the reps, similar from all of the different groups, and everybody would weigh in. It was typically chaired by a flight director. There was representation from the crew office, and all of the MOD, and others maybe brought in.

More or less, that one was the actual operation of these joint flights; what were things that needed to be thought of? Maybe new procedures needed to be written. Maybe there were better ways to do things than these people who were proposing. It was any number of things, so it wasn't definitely the crew procedures in that case, but it was more or less looking at the flights that were coming up as they began to actually plan how they would carry them out. Those flight objectives I talked about in the flight requirements documents that were handed down from the program. They would start earlier, before the mission even flew. With these working groups, "Okay, how's this going to go? What's your proposal?" Whoever it was. Sometimes the training people would be the ones coming in. "We propose, because this is a new system, here's how we're going to train it. It's going to require, however, engagement from this team, and can you guys support?" It was those sorts of negotiations. Sort of thinking ahead of time and planning for the joint operations and how they were going to go.

ROSS-NAZZAL: I thought we'd turn our attention to *Columbia* [STS-107]. Wanted to ask where you were on February 1st of 2003.

REED: I was asleep. I had moved in June/July of 2002. I had decided to leave NASA. Quite frankly, I wasn't having fun anymore. Not that it was all about the fun, but it was beginning to

be the compressed schedules, training all the time, and not getting a lot of time off. Also, I was getting older. One of the things I was thinking in my mind is, "Wow, I have so enjoyed and just loved doing what I got to do on Shuttle." It was the weirdest thing. I remember coming back from a sim, sitting at my desk, and you know, "This is all going to end one day. The programs are going to go away, and I don't want to be 50 years old trying to find a new job." I don't know why that popped into my head, but it did. It got me thinking. Every couple of years I had a friend who used to work here, had left, and gone to work for Space Command in Colorado, then moved from there to work with this consulting firm that supported military space. Every year she'd call me and say, "Oh, would you like to come up here? They would love to have you if you want a job." I'd say, "No, I'm still having a great time; I don't want to leave." She finally called that year. I was like, "Well yes, let's talk about it." She goes, "No, really. You ought to consider coming." I said, "I said yes," because I had said no so many times.

I went up there, interviewed, got a job, and I moved to Colorado. I was also getting very worried that we were pushing a little too hard. Things were happening. It just felt like we might have another accident, and that's the honest truth. I had no idea it was going to be as quick after that as it was. I was not feeling real comfortable, and it just was a good time for me to leave.

I was up there, and it was a Saturday morning. I was asleep, and I don't keep the phone ringer on in my bedroom. Something just woke me up. I heard my house phone ring, and then immediately heard my cell phone ring, two different rings. My friends know better than to call me on a Saturday morning, that early, which would have been before 7:00. I'm like, "Darn it, they know better than that," and I rolled over. It got quiet, and I'm like, "All right. Phew."

Then they both started again, and I thought, "Okay, that's weird." I thought something had happened to somebody in my family. I got up and thought, "Well I need to go see what's

going on." When I got to the place where I had the house phone and I saw the caller ID, it was my dad. On the other caller ID it was my best friend here in Houston. I actually picked up her call, because I didn't want to talk to my dad; I thought somebody had died in the family, and I was just going to be a mess. I picked up the phone, and she said, "Lisa, they've lost contact with *Columbia*." I'm like, "What do you mean?" She goes, "They lost contact with *Columbia*. It's gone." I said, "What do you mean?" She said, "Turn on the TV."

As I'm on the phone with her, I walked in and turn on the TV. It just so happened that the news was on there, and I saw this helmet laying on the ground. They were already flashing bits of debris. Don't remember too much after that, because I just kept saying to her, "No," and she said, "Turn on the TV; turn on the TV." I did, and the first thing that I saw was a piece of crew equipment that shouldn't be on the ground somewhere in wherever it was. I still didn't even know where it was at. I don't remember much after that. I just fell down [to my knees].

After that, I called another friend who was out in California, who I knew probably wouldn't know. Woke her up even earlier. It kept ringing, and then I kept calling her back. Same thing, she finally picked up the call. We knew everybody onboard, and several of them were people I viewed as close friends over the years. Really, really hard. I know one of them she had grown up with, and was a very, very dear friend of hers, so I wanted her to know.

There wasn't much to say. I called my friend who was the team lead, because I knew she would be a mess. She was a mess. They [she and the 107 training team] were in the SCA [Simulation Control Area in the MCC], so they [had already] locked down the Mission Control Center [as part of the contingency procedures]. Well, the SCA's in the Mission Control Center. They [the training team] all were in there, and when they got out, after they had quarantined everything [all the flight data and records. [Normally the training team] would decorate the

hallways, the big, long hallway in Building 4 South, so when the crews came back you always had that ready for them [to welcome them back]. She, bless her heart, because her team was just a mess, went over and took down every piece of that [the decorations] then worked with the Astronaut Office later on what could they do [instead given the loss of the crew]. That was one of those rites of passage, that hall decoration is how you show how much you love your crew, and how great the training was, and welcome them back home. It was going to be stark to not have it there. What they came up with, which I thought was brilliant, that she did, was they got butcher paper and they let people write their feelings. People would come [and pay tribute on the wall]. They put pictures. Some of the pictures that they had from the mission and everything, but it was no longer the fanfare and the welcome home kind of thing. I thought that was really good [to give the people some outlet to express their grief and feelings]

That's where I was [Colorado]. I immediately wanted to be back in Houston, and I remember my new boss in Colorado Springs called, and said, "What can we do for you?" I just apologized. I said, "I don't know at this point in time, but I know I'm going to want to go home." He said, "Just let me know." He said, "Do you need anybody to come sit with you?" I said, "No, I'm okay." I was never okay, but of course I'm saying I'm okay. I was in shock. Quite frankly, I was in shock. The rest of the day is a blur. Lots of parts of that time are a blur.

I was just really devastated because I had just been talking to Dave [David M.] Brown not too long before that. Rick [D.] Husband had come to Colorado Springs, and a couple of us that knew him, we met at the A&W and had burgers. He flew in real quick, and he was flying back out. He had come to Air Force Space Command for something. KC [Kalpana Chawla] was just a dear friend. All of them were great, but those were some that I just really, really liked,

biked with, sang with, and just did stuff away from work for many, many years. From the time they were AsCans [Astronaut Candidates] until they flew. It was a difficult time for everybody.

ROSS-NAZZAL: Then you were somehow contacted and asked to be an investigator. How did that happen?

REED: Yes, I flew to Houston for the memorial service. Then I flew back home. The memorial service was beautiful and awful all at the same time. Wanted to be there and be with my friends. The thing about being in Colorado Springs at the time—no one meant any harm—they knew I'd worked at NASA, but they kept coming in and showing me pictures of debris. It was not what I needed to see. They didn't know that. They were just like, "Do you know what this is? Wow, look what they found." I'm just like, "Eh."

At a certain point, about two weeks after the accident, I walked in to my new boss's office, and I said, "Look. I need to take a little time off. I need to go home and just sort out whether I can stay here, or what I can do." I really wanted to come help out in some way. I had a lot of friends who were working out in the field collecting debris. We knew the Orbiters, just like the guys at KSC, so we would be able to identify and maybe help lead some of the teams. That's what I was wanting to come home and do, go in the field and help lead some of the teams, or work on some of the teams and try to find out what went wrong. That was first and foremost in my mind, and everybody that I worked with minds. All you wanted to know is, what happened?

Also, I couldn't even sit in my office without just bursting out crying like three times a day. I'm like, "Okay. This is not any way to work." It was all over the news. I was just a mess.

I flew back home. I stayed with my parents. It was good to be back here where I could be with friends who understood. We would just sit. We didn't even have to talk, because we all knew what we were all going through. It was our worst nightmare. We were able to talk when we needed to, and it was a safe place. That was helpful for me.

One day I'm just sitting in my bedroom at my parents's house. I was staying in their guest bedroom. My cell phone rang, and it was a gentleman. He said, "Hi, this is Dan so-and-so from the *Columbia* Accident Investigation Board." I'm like, "Why are you calling? "Oh crap, why are you calling me?" I didn't say that out loud, but that's when I go, "Oh, okay." He said, "We got your name from some folks working at NASA and said you might be a good person to come work on the *Columbia* Board with us, on the group that's investigating the training.

I said, "Well, yes. I'll help out." Because I was coming down and wanting to help out. I actually had been on the phone trying to figure out how to go out into the field. Long story short, he said, "Do you think your bosses will let you off for that long?" I said, "Well, as it turns out, I work for a consulting firm, so I'm pretty sure that if you guys want to get in touch with them, I can work for you," because they were going to pay me anyway just hire me as a consultant. I called my boss in Colorado Springs and made his EA [executive assistant] get him out of a meeting. She's like, "Well he's in a meeting." I said, "I think he's going to want to hear this. Look, they want me to do this. They think it's only going to be a couple of weeks."

He put them in touch with contracting people, and I showed up the next day at the Regents Park building where the CAIB [*Columbia* Accident Investigation Board] was housed. They were trying to find a desk for me, because it was just this hub of activity. There were people coming and going. It was, like I said, just flurry of people everywhere. They sat me in a room with people who each had 50-pound brains. Hard engineering that were talking through

equations, velocities, and impacts. It was fascinating stuff, but when you think about the context in which they were talking, I was like, "I don't want to be in here."

Then they moved me into what was known as Group Two. They had Group One, Two, and Three. Group Two was looking at operations, and safety, and training. That's what they were doing. They came to me and said, "We have to go through all this quarantine data from the training records, the stuff in Mission Control. Half of it is in code, basically all the NASA acronyms. We can't read this. We've tried, so we were talking with folks over in MOD and your name came up."

Basically, they needed someone who had recent experience in the training division, but was not a contractor on the Shuttle Program or working for NASA. I was six months out from doing that, so someone gave them my name, and that's how I did that.

My first task was looking at all the training records and ensuring that all the people were properly trained, from the crew, to the flight controllers, to the launch controllers, the mission personnel that support in any way. If there were training requirements for them, did they meet them? Had they been trained properly? NASA has always had a very good training process,—I won't say it was quick. Look at the training file of each person. Look at the requirements book of what they needed to take. It was all in order. They said, "Well, okay, next thing is to go look at the data from MCC."

The guys that were on Group Two with me, it was led by General Kenneth [W.] Hess. He was one of the board members. He was the head of the Air Force Safety Center [Kirtland Air Force Base, New Mexico]. They were accident investigators. That was part of their job. If there were aircraft accidents or incidents from the Air Force, his team would do that. Also Steve [Steven] Wallace was a board member on Group Two, and he was the head of accident

investigation for the FAA [Federal Aviation Administration]. The week I was there, they added Sally [K.] Ride, so she joined that week. She flew in and became the third board member representing Group Two.

There were some Air Force Safety Center investigators in the room with me. There was an Air Force PhD psychologist from a standpoint from a lot of the crew resource management and studying accident investigations and how people react and things like that. There was an NTSB [National Transportation Safety Board] investigator and an FAA accident investigator. Now I was the only one that had the NASA background, so that was good, but we're talking about these investigators. For example, the FAA guy had investigated the JFK [John F. Kennedy], Jr. airplane crash and the Twin Towers.

It was a little intimidating, but they all had some great experience. They were all wonderful people and realized that I was not in a fun position, because I was actually going to be looking at information about friends. Not only the ones deceased on the crew, but friends that were still here [at JSC]. It's hard to grow up in MOD and not know a lot of the people and the players that were there. They were all very nice, and they introduced me to the world of accident investigation. You have to park the emotional piece. You can't write emotionally about it. You need to just stick to the facts, and that's what needed to happen. They realized for me that this was an emotional event. They were very helpful.

We went over to the Mission Control Center. I'll never forget the day we went there. I went with two of the Air Force folks from the Safety Center. We were all just going to go look at the data. As we pulled up, there was a huge—looked like a tour bus—in front of the Mission Control Center. That was weird at that time, because there was a guard check. I'm like, "Maybe it's a Space Center of Houston tour." Then I saw Cady Coleman walking up toward the bus.

She had been a crew member of mine on STS-93. She came over and gave me a hug. I'm like, "What are you doing?" She goes, "Oh, these are all people who were out in the field. They just came in from Hemphill [Texas] and we're just going to give them a briefing and talk to them about NASA and give them a tour.

All these people are getting off, and you can tell they came in the clothes they were searching in, so they look like they've out in the field searching everything. I said, "Well that's pretty cool." You had these people out there just for the love of the program. Were volunteering their time. Everything from Forest Service people and firefighters, and just normal, everyday Americans. I just thought that was so cool. Here it was, it was very personal to us, but you realize it's very personal to them, too. These are our American heroes in their minds, and something America's very proud of. The space program is this shining example of what Americans can do. There they were, giving it their all. I was standing there talking to her, and she was shaking their hands. I joined in. I was like, "Thank you." Because they were out trying to help us. Just shake their hands and say thank you for doing this. No, they didn't have to. They volunteered their time. That was very touching.

Then we went on into the Mission Control Center, and luckily the guys I was with—you've probably been in there, but there's the turnstiles and getting around here and there. I don't know what they would have done if I hadn't been with them, because they're going [demonstrates]—I'm like, "No, no, come this way." You don't know; is that an in-turnstile? Is that an out-turnstile? Those are the outs, and this is the in, and you got to put your little card in here. Then we were met by the *Columbia* taskforce, so a NASA rep who took us back.

I was really surprised. Basically they had everything in the area off of the loading dock there at MCC. There was a JSC security guard at the door. They said, "Here are all the boxes.

We'll leave you to it. Only requirement is you can't take anything out, but we've got a copier in here for you." Blue paper, so that we could print off anything, but that way they could tell it wasn't the real thing we were carrying out. I understood all that, but I just thought it was funny. It was all sorted out when we got there. We sat down. We spent two days going through.

Basically what it was, it was flight log books. Each console either kept it—at that time, they could have kept it electronically. Some of still use the old log books that I was familiar with. It was any number of that. Looking through. That was from every position from flight director all the way around the room and all the backrooms. Reading through those for anything. You don't know what you're looking for but anything of note. There was the flight log books, and there were some tapes and things like that.

When I first got here, the front page of *The Houston Chronicle* was talking about all of these mission controllers what-if-ing about the landing gear, and how did they know that this was going to happen? I immediately kind of chuckled. They didn't know it [was going to happen], it's just they had a failure, and the way we train them is you always think of what's the next failure and what's the next failure so that you plan for the next worse case. If it's critical, you handle that first, but then you're going to be looking at what's the impact if the next thing happens? It was just good flight controllermanship. They were doing their thing, but to the world, it looked like they had some idea and they didn't flag it. Not that at all. That was a flurry of activity in the paper for the first few days, and I felt so sorry for them.

I knew half these guys that were talking all that stuff. They're like, "Why did they wait to the last day to bring it up?" I realized when I got into those books that one of the reasons they waited until the last day is, for whatever reason, their being able to play the video on their particular console was broken, and they had turned it in to the IT [Information Technology]

guys. It didn't get sorted out. They had gone back and forth with whatever the problem was. They finally got it fixed the day before the landing. That's why then all the emails started flying, once they got too look at the video of the foam hit. They began to do their what-if-ing with each other and get other people involved. It made perfect sense to me. They weren't holding this, they just hadn't seen [it]. They saw it, and then they're like, "Oh, well this could be bad if it's all these things," but they had no idea the exact thing that happened.

As an engineer that is trained as a flight controller, you're going to be thinking, "What if it damaged something on the underbelly of the Orbiter? What if it damaged the landing gear door? What if it damaged this? What if it damaged that?" They weren't thinking, "Oh, it's put a hole in the reinforced carbon-carbon," which we learned later. Hot plasma got in there, and there was a failure. Thank goodness I knew that, but also that the FAA guys told me, "You've got to remember, when you're reading all these things, they don't know an accident has happened. You've got to be looking at everything—don't attribute to them some pre-knowledge, because they don't know the accident's happened." As the mission's going on, you're seeing what they've written in real time, and everything was fine. They kept bringing me back to that, and it was an interesting thing.

That was a couple weeks in. Then I was wanting to get out of there. I'll be honest with you. My duty's up, I'm ready to go home. I didn't want to stay. Because every day one of the guys in my group was working with the medical staff, and I finally had to tell him, "Please quit." Because he was asking me questions, "Okay, the suit. Tell me about the suit. Would they have gloves on, would they not have gloves?" I'm like, "Okay, I'll talk to you about how things work, but don't show me any pictures, number one." They kept all those quarantined, and I don't think he would have, but I just wanted to make sure. "Don't ask me any questions that are personally

about someone on the crew, but if you want to know about any of the equipment, I'll talk to you or get you in touch with somebody that knows it even better than me." He said, "Okay."

I'll never forget, one day he was sitting over there. Because each day, pictures would come in from the field, from where they were searching and recovering debris. One day he was sitting behind me, and I heard him say, "Lisa, are there fire extinguishers onboard the Space Shuttle?" I said, "Yes there are." He goes, "Well, what do they look like?" I said, "Well, they're kind of short—not big ones—but short. About this round. [Demonstrates] They've got a little tube on them so they can shoot into the fire hole behind the panels. Got a little label on it." He says, "Well come look." I look, and there laying in leaves, like some leaves somewhere in a field, there's a pristine flight fire extinguisher from *Columbia* laying there that someone had found. It still had the markings on it. I said, "Yup, that's it." He said, "Okay, I was just surprised they had them." I'm like, "Well of course they have them. You got to be able to put out a fire."

ROSS-NAZZAL: Did you just stay those two weeks?

REED: Well I just wanted to stay those two weeks. I was actually packing up my desk and getting ready to fly back to Colorado Springs. I'm a little like, "Phew." The exec for General Hess, so another Group Two member, came walking down and he said, "General Hess would like to talk to you." I went in. I don't know if he talked to somebody or he knew or whatever, but he said, "I hear you're leaving today." I said, "Yes, sir, I am." He goes, "You don't have to call me sir." I'm like, "Well everybody calls you sir." He was very nice. He was actually a

really, really sweet man. He says, "I just want to know something. Tell me why you left NASA."

I told him my story, which I told you earlier: why I decided to leave and all that other stuff. He said, "I'd really like you to stay." I said, "Well, okay. How long?" He goes, "Until the end." I said, "Well, how long is that?" He said, "However long it takes." I really wanted to go home and sleep in my own bed. I had gotten my dog down here, but she was living in the hotel while I was gone, the Candlewood Suites. I said, "Well, let me go talk to my boss. See if it's okay if I extend because they are my employer. I don't know if they have work for me." They said no [pressing work I needed to get back to], so I signed on [to continue with the CAIB], because I'm still not thinking it's going to be really close to six months at this point in time, but that's what it turned out to be.

By this time, you're getting more data and you're timelining things out. You're beginning to see questions that pop up. "Okay, we need to go look more into this." At that time, he [Hess] had assigned the FAA investigator to look at the Mission Ops timeline and how things went, and the decision-making behind it. He assigned me to work with him. Again, it was a lot like I was the translator. I could translate some of the things they were reading, seeing, and explain things, the NASA-ese. If people were talking about procedures or this or that, I could translate things for them. He and I began to work together on just putting together the Mission Ops timeline from a what happened when, who knew what when, what emails. In addition to all of the stuff that's quarantined at Mission Control, we could make a request. "Do you have the training records for these positions?" They [NASA] would send them in. "Can you provide us the emails from these roles leading from this time to this time?"

We would make those requests through our *Columbia* Taskforce representative, which was Kelly [B.] Beck. She was the lead flight director for STS-107. My heart really went out to her because she was the lead on that flight, and that was her crew too and her team. She had my sympathy the whole time. She was very professional and did a great job, but there were days I know it was probably as tough on her as it was for me. She would make the request and they would get those things for us. We just began to look at that and put together a timeline.

One of the things I got assigned to do was listen to all of the flight audio. I believe it was Flight Day 2, don't know for sure, something flew off of the vehicle. The crew reported seeing something floating away from the vehicle. They asked me to hone in on that and if we could figure out what that was and what became of it. I worked to pull that together. Gave them my thoughts on what I heard, and was also able to get—through the request—whatever they needed to see about that.

The Board would get together every morning at about 8:00. All the teams would come in, and if there was anything to be briefed on, the board member that you worked for would say, "Tomorrow you're going to talk to the Board about your findings thus far on this." Every day there was something like that. Then they would break at about 9:00, and everybody would go off doing their different investigations.

One of the guys on our team was also looking at the history of foam coming off the vehicle. I'll never forget. As the requests would come in, this data was coming in from each flight. He would get the history. If you imagine all the flights up to that point, he had mounds and mounds of data. It was his job to put together the history of the foam from start to finish, and how it was handled.

I was working with the FAA investigator on the Mission Ops stuff. We spent a lot of time either going to interviews, going to look at the facilities. They needed to understand, for example, where was this person in relationship to this person's office because they're talking? In other words, sometimes it was really I need to understand how this was going on here. Where is this backroom flight controller who's talking to this other one? I'd take them and show them. "Just so you understand, these guys are behind a wall here, so they're on a headset. They're talking." They're like, "Okay." Sometimes it was that miniscule that they were trying to figure something out, and I'd be explaining, "No, it's not what you think." Sometimes it was just easier to drive over there. Finally I took them to try to explain to them, number one, you might be in very close proximity, but you're separated by a wall, and you're talking over a headset. Or you may be separated by a continent. You weren't in this case, but you're not always having these face-to-face conversations. You're also looking at a lot of data, and that's what you all might be talking about.

At a certain point, when they were beginning to get some rough idea of what was going on, there was a whole group looking at just the actual cause—the foam—or what was it? They're beginning to hone in on the foam. We're still looking at how the operations went. I had already closed out the training stuff and turned in my write-up; they would figure out how that went into the report. I wrote rough drafts of what went into the report to give to them and to the members of the Board. Then they would decide what pieces they wanted to put in. There was a group of editors that worked with them on everything that went in the report.

We had a lot of feedback from the interviews that seemed to reflect that people felt that there was some schedule pressure, if you will, for that date, for the end of the Station program. I got assigned the task of doing the schedule pressure investigation. This was toward the end of

my—I won't say the end, because it was still another two months—but toward the end of my tenure, I guess, because I'd already been there four months. They said, "We want you to look and see if there was any [evidence of] schedule pressure in this." It was going to feed into that whole mission decision-making [piece of the investigation]. Because if there was schedule pressure to launch these things at a certain time, it can affect decision-making was the basic premise there.

In doing that, I started looking at every schedule I could get, first off, just to see what were the schedules. That meant Orbiter processing schedules from KSC, training schedules from these guys, crew training schedules. Just what were the schedules around the flight that we needed to look at?

There were people who had done just initial interviews, because they just began to interview players right after the accident. Those were all transcribed. If any of the board members remembered anyone speaking about, "Oh, well we were a little bit under the gun," or any kind of little thing, they would say, "Go talk to this person more, or go talk to this person more." By this time, and working for a couple of months with the FAA guys, they literally had a whole timeline on one whole wall—because we were in a big bullpen, just one big conference room that had a bunch of desks around it and a big conference table in the middle for Group Two.

We also had beads hanging in the door and lava lamps. People were doing things to break the tension. All these guys were living away from their families. They were not from Houston. You're staying in hotels and you don't know the area, you're missing your family and your kids. One guy came in one day, and he just set this lava lamp on his desk. Everybody's like, "Where did you get that?" "Target." The next day, another guy gets one. I started getting a

lot of crap for not having a lava lamp, so I bought one. We became known as the lava lamp room. It was a little bit of levity in a really awful situation.

That's how we handled it, and we also had an admin named Helen who was great. She kept us stocked—that big, long conference room. We had those meetings with the Board every morning, but then the group would meet every afternoon to close. This was usually closer to 6:00 p.m. to talk to the group members about that day's findings, just talk through things and answer their questions. She kept Goldfish, chips, and Hershey's Minis in the table there. That was what the room was like.

These guys, on that long hall, had placed this timeline. It was butcher paper, and each day they would find something, they would just put it on the timeline. They wouldn't ascribe any, "This is what I think it means." It was just, "This email here." Or, "This flight event here." They would just put it on the timeline. Lo and behold, after a certain point in time, you could kind of see how this decision was made here. It began to tell the story. They kept telling me that. They've been doing this for years. It began to tell a story, without anybody [filling in the blanks]. It was just a fact. A fact, a fact, a fact, a fact, a fact all along this timeline. The story began to speak itself. That's what I found fascinating. I'd never done anything like this. Over the months, that timeline got filled with more and more stuff. If there was something they wanted to dig a little deeper into, they would tag it, and somebody would be sent off to work it and talk to people and understand it more. It was pretty amazing, that timeline.

It was similar to the engineering timeline that was on a big hallway out there of the flight. How it broke up, the pieces, and where they were found, to tell the physical story of what happened to the vehicle. Here was one that was telling sort of the emotional story, or the people speaking and doing their job kind of story, not the vehicle, not the engineering, not any of that.

That was beginning to take place. You had both of those that you'd see every day. They got more and more fleshed out. It was pretty fascinating to actually see how that, over time, transpired and grew and grew and grew. Someone just needed to put words around it, because the story was there. Pretty fascinating.

Anyway, I began to work on the schedule pressure piece. In the middle of all of that, the person I was renting the house from in Colorado—because I was going to rent the first year I was there so I could see where I wanted to live, and then buy—who had told me, "Oh, you can stay as long as you want. We're not going to need it back for years, because I've remarried, I'm living with my husband," calls in the middle of May and says, "Well, your lease is up in June and we need you to move out because we're moving back in." In the middle of all of this, I've got to go find a house. I did that, but I told General Hess, "I have to go back to Colorado Springs, but I can take my computer. I can work there and I can do a lot of this stuff as phone calls. You guys can send me the data electronically."

They agreed, and I went up there, and I had found a house that was already built. A new one, but it was built, and it was in a good area. I loved it, bought it. Believe it or not, I had my mass of friends who lived up in Colorado Springs—it was like Acme Moving Company. Acme Moving comes in, they move me in one day, and a good friend from the Army who was up there. My friend Michelle Truly and her husband Mike, and Susan [J.] Helms who was *Expedition 2* crew member was now up there, had gone back to the Air Force, and Brian Lee, who was an army colonel. They helped move me in one day and get me moved in. I didn't have all the boxes unpacked, but my furniture was in. I sat with my computer on a box and did a lot of my writing and phone calling from a box and my laptop.

Just before I'd left, though, I had begun to look at all those schedules that had come in. I began to notice it seemed like number one, the mission training schedules were really compressed. For example, the flight controllers, every year or every couple of years, they have to recertify. It's a proficiency requirement. There were a group of people that their cert records had not been signed. That had to be called out in the report. It was called out in the training piece. I thought that was weird, but in looking at it they had continued to work straight through and had no problems. These were very experienced, so there was no loss of proficiency in other words. They weren't off console where they were going to get rusty. In fact, they were on console a lot, working all of the missions.

I stated that in the write-up, because I didn't feel like the fact that they weren't done—but to me it was a little flag that because of this, they're not able to fulfill the requirements. Either change the requirement to say, "If you're continually on missions—" because here it looks bad if you don't get this requirement filled. They didn't fill it because they were actually doing the job that they're trying to prove they're proficient in, and they're obviously proficient. Those kind of things.

Then I began to see the Orbiter. To me, it was almost like there was this little dance going on, because they were having to move one in, and take one out, more moves than I had normally seen in the past, and just knowledge that you had of that. Then you began to see emails from working groups, or meeting minutes from meetings about Space Station, and them needing to move stuff either on the Shuttle or off the Shuttle. There's a weight limit to go up, so sometimes you're trading things off. A lot of this all just kind of came to a head.

I'll never forget. I went down the hall. When Sally Ride joined the Board, obviously she had a NASA background. She spoke the lingo. She understood what a team lead was, what I

had done, when they told her. I was her person she'd come to first, there in the room, to ask, "Well how do they do this now? Because I know this is how they do it." I'd say, "Oh, they still do it the same." Or, "Here's how they do it now."

I was beginning to see a picture in my mind, because I was laying my timeline out on the table in the form of the schedules. It was very late one afternoon, just before I left. I went down there, and I said, "Sally, do you mind coming down here and take a look at this? I just want to see what you think, because you know what these are. You'll know them when you see them. Just give me your impressions." Because I already had my impressions, but I was really not wanting to be biased in any way, and I didn't want to bias her. I just wanted to see if she and I were drawing the same conclusions. She's like, "Sure." She came down there, and I kid you not, this is a very long table. It's probably about 20 feet long. Everybody was gone. I said, "Well just start here. I've got them all laid out, and you just take a look at these."

I'll never forget. She kept grabbing handfuls of Goldfish, because we had the Goldfish and the candy. She would have her hand like this [demonstrates], and she'd be popping them. She'd read this schedule, or this document from NASA, and she was just walking down there, and she'd just be popping them [the Goldfish]. It was like, "Hmm." Kind of like this [demonstrates]. All the way down. When she got down to the end, she tells me everything I thought. Verbatim. I didn't say one word to her other than, "Tell me what you think and what you see here." That's when I thought, "Okay, I think we can start writing something here." I just laid out the actual NASA documents based on the flight and when they came out and the timelines.

She was the one assigned to work with me on this piece. She didn't work on it, but when I wrote, all of my drafts went to her and the FAA investigator. When I was in Colorado Springs,

when I got back there, I sent my first drafts, and she would wordsmith it. I've actually saved some of the emails [she sent me], because heck, this was Sally Ride. She got selected when I was a senior in high school and flew when I was just a sophomore in college. She wrote a note and said, "This is great." By the time the draft got ready to be sent to other members, she actually wrote John [M.] Logsdon who was on Group Three. They [Group Three] were [writing] chapter five, and we [Group Two] were going to be [writing] chapter six. Part of my stuff, in the schedule pressure section, ought to go in theirs. She wrote to him, "Here's the schedule pressure write-up. I think this part of Lisa's write-up needs to go in section five, and you're not to change a word of it." I saved that email because that just made me laugh. He wasn't going to say no to Sally Ride. I thought that was really nice.

It was funny, because she was traveling back and forth. She lived in San Diego, so she would go home periodically. When I was working, I'd go home once a month, and then I had that extended time when I was moving. I'll never forget, my car battery's dead, so I went to Sears to get a new DieHard. I'm standing outside, and I'm in Colorado Springs, a beautiful city. I'm looking at Pike's Peak, and my phone rings. It's Sally Ride. She goes, "What are you doing?" "I'm at Sears." She goes, "Oh." I said, "But I am looking at Pike's Peak." She said, "Oh, well, I'm at home writing," and she said, "but I'm looking at the ocean." She said, "Well that's good, at least we got something nice to look at." We would call back and forth, and she would ask questions. There was a little bit more of investigation, or interviews, or call up people to find out more. We would get things from them, and it's like, "I have a few more questions." It was that kind of stuff.

Then ultimately, I got a call in July. That was June, so probably mid-July. The CAIB had moved. It had left the offices here in Houston. All of our documentation, had people from

the National Archive come down and take all of our computer hard drives and salvage all of that. That's stored somewhere in the National Archive. I'm assuming, for historical reasons, I don't know. Everybody's computer, they had to come by. Also, if we had hard copies, they copied every bit of hard copy that we had. All of that was preserved. Then the CAIB moved, because they were then having to go to Congress and do hearings. People were beginning to want them to talk more about this, what it meant to NASA, when was it going to come out [in the report], and what's the report going to say, all of that kind of stuff. There was more requirement for them to be in the DC area. I got a call, and said, "Okay, we like your schedule pressure draft, but we need you to come up here because we're in the final push."

I went up for about 10 days, it was near Arlington. We were in an office there. Everything at that point in time was pretty locked down. It was locked rooms. You had to have keys and key codes to get in everywhere. A lot of people were trying to find out what the Board was going to say. I don't mean NASA, just everybody. There was press. We had to shred. You can't leave anything on your desk. It was a little craziness. I never quite worked in an environment like that.

Sat in there. I wasn't quite getting the schedule pressure piece. I could tell that the write-up was not exactly what they wanted. I sat down and said, "What is it that's missing?" They said, "Well, it needs to tie together with the piece that comes before and the piece that comes after." I said, "Well I haven't seen those. Do you have drafts?" They're like, "You haven't?" I'm like, "No, I've been in Colorado Springs." The minute they gave it to me, I read those, and I'm like, "Oh. Okay." I was writing in more of a college paper type of format. This was more of a story. I'm like, "Okay." I went back, and I just outlined it differently and told the story.

They liked it, and that's when Sally sent the thing. "Use this, but don't change it. Don't change a word." She was actually pretty funny. She had a wicked sense of humor.

Anyway, there was a sociologist on the Board who had written a book on [Space Shuttle] *Challenger*. She was brought back in [to the CAIB] by the *Columbia board*. Her book was called—well it was the one that had the normalization of [deviation]. I can't believe I can't remember it. *The Challenger*—

ROSS-NAZZAL: I think it's *Challenger Launch Decision*.

REED: *The Challenger Launch Decision*. Yes. That's what I was thinking.

REED: Diane Vaughan. Anyway, she was writing a piece in the next chapter about the comparisons to that. She was actually waiting on my piece to get finished to finish her piece. She had a draft. And when I read her draft and I read my draft, that was the first time I really understood the parallels to *Challenger* that had happened with *Columbia* based on the findings of that piece of our group that was working on that.

Whatever you were assigned, that's what you were working on. We would talk a little bit at the end of the day, but I had no idea. When I read her piece, I'm like, "Wow. Okay. That's a little scary, but it makes you think how 19 years later we trend back into doing some of the old behaviors that were unintended consequences of when you've got really can-do people." That's the way I view it. At NASA, it's one of the greatest environments to work in. The teamwork, and just the mission and the can-do attitude and spirit to pull off these great things. This was just Lisa's perspective on it. You lose perspective on those unintended consequences of things that

you're doing to pull off these really wonderful feats and technological events. It's kind of interesting.

I finished that up. I hightailed it back to Colorado Springs, and about a month later, I woke up, getting my coffee, and I always turn on the news in the morning. Headline that came across—because the Board had released the report that morning—and the headline that was coming out of the TV was "*Columbia* accident investigation says schedule pressure may have been a contributing factor." It was a strange day. I hadn't actually read what was in there [the final report], but they had a whole set of editors that one-voiced [made it sound like it was written by one person] the whole report. They went through and did everything, but it was not edited too much from what Sally and the FAA guy and I had done. It was pretty much the same.

ROSS-NAZZAL: That's Section 6.2?

REED: 6.2.

ROSS-NAZZAL: Did you feel like that six months was a healing process for you?

REED: No, no. Actually it wasn't. The healing came later, and it was because I almost had to—as much as I could and it wasn't easy—put that aside. Dealing with the grief, feeling it and healing it. I wouldn't have been able to deal with a lot of that and then write about it. In other words, my emotions would have been too much involved, so I had to separate that. I had a long little talk with myself in my head when I was choosing to accept the CAIB. "Are you going to be able to do this?" Because I am a bit of a feeler, I love my friends. I feel things deeply. Not

that most people don't, but I'm an expressive kind of person. I cry, and I laugh loud. I get mad. I wanted to make sure I could do that without doing damage to myself, but more importantly, I wanted to do that so that it did the right things for my friends that died, for my friends that remained, and the program that I loved.

I postponed that. When I got home, I have to say, I felt like I helped, number one. I'm not sure if that's everybody's opinion, but I felt like I'd done my part. Then it came over time, but I began to really feel that delayed effects of the grieving. The loss and the change of the program and all that other stuff. That was hard. It hit me hard. I had some long months after that. It was probably a couple of years, overall, before it finally got to where I could not bawl my eyes out if I saw a picture of the crew, or every anniversary, or things like that. I had not allowed that, so it was only natural it was going to come up some way.

ROSS-NAZZAL: I'm looking at the clock. I should have asked you. It's 3:30, so I wasn't sure. Do you have plans with your friends?

REED: I do. I probably need to—well let me just see if they've—they were supposed to tell me.

ROSS-NAZZAL: We were just talking. I thought, "Well, it'll just be a few more minutes."

REED: I told them 3:30. We may need another [session].

[End of interview]