NASA Johnson Space Center Space Shuttle Program
Tacit Knowledge Capture Project
Oral History Transcript

Robert C. Doremus
Interviewed by Rebecca Wright
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WRIGHT: Today is July 2nd, 2008. We are at the NASA Johnson Space Center to speak with Bob Doremus, Deputy Manager of the Space Shuttle Safety and Mission Assurance Office. The interview is being conducted for the JSC Tacit Knowledge Capture Project for the Space Shuttle Program. Interviewer is Rebecca Wright assisted by Sandra Johnson. Thanks for taking time today. We'd like for you to start by telling us how you first came to work for the Space Shuttle Program, and then how your duties evolved.

DOREMUS: For the Space Shuttle Program I joined in May of 2004. I had previously worked in the Orbital Space Plane Project. I worked there for about ten months, a very brief and intense exposure to program and project management. Prior to that, from 1984 to 2003, I was a flight controller in Mission Operations in the Systems Division in the Mechanical Systems Group. I had started in 1984. I had graduated from Texas A&M University with a mechanical engineering degree in 1982 and had worked on the South Texas Nuclear Project for Bechtel Energy Corporation for a year after college. Then in '84, I was hired by Ford Aerospace to come work here as a flight controller.

My flight control experience, you can see up on the wall I have pins. There's 51 of those. I supported 51 missions as a flight controller. It was all in the Mechanical Systems Group. We had—we, I'm speaking as we the Mechanical Systems Group—had responsibility for all the mechanisms on the Orbiter, the structure. We had responsibility for auxiliary power units, which are these little gas turbines that burn rocket fuel that provide power for the hydraulic system that the Orbiter needs in order to operate like an aircraft. We had responsibility for the landing gear, the brakes, the nose wheel steering, the drag parachute.

Hydraulics system does a whole lot of things, runs all the aerosurfaces, and works the brakes and nose wheel steering. The mechanisms included payload bay doors, external tank doors, vent doors, Ku-band antenna. We also had responsibility for the docking mechanism when that was added. We had responsibility for crew systems, all the stuff the crew used on orbit that would frequently break down, the cameras. In fact, it was usually pretty terrifying when we'd hear a call about a camera because those were tricky.

In all the areas, being a flight controller you're expected to be an expert in all those systems. And that's the minimum expectation, is that you have expert level knowledge. Then in order to operate as a member of the flight control team you need communication skills. You need to understand how to work as a member of a team and how to communicate effectively because your expertise doesn't do anybody any good if you cannot pass that on in an understandable way to the rest of the team. You learn how to do that very quickly.

I began work in '84, and I supported the first mission in 1985, STS 51-D. OJT [On-the-job training], my first certification was [STS] 51-J, which was a classified mission for the Department of Defense. I worked five or six of those. I don't remember exactly. But those were really different also.

Working as a flight controller, what was that like? It surprised me coming from Bechtel to NASA, the office environment itself. I felt like I'd stepped back in time from a modern up-to-date cubicle environment to old-fashioned desks and binders and things like that. But the training was just outstanding, and the way we trained was through personal study. Studying drawings, studying briefing materials about all the different systems and about spaceflight, about how launch and landing and orbit worked. Also we learned from our fellow flight controllers. The senior flight controllers would train the junior flight controllers.

Then a huge component of the training was integrated simulations, which took place in Mission Control [Center]. We would go into Mission Control, and the flight control team would be on console. The flight crew, the astronauts, would be in one of the simulators training, and there would be a computer driving the data that the flight crew saw and the data that the flight controllers saw on console. These very devious-minded training personnel would be putting malfunctions into the system so that we saw the same data at the same time and practiced how to handle situations in flight.

We spent almost half our time on console training. So you're in an office environment half the time, and the other half the time you're over there in Mission Control. I will never forget the first time I went in Mission Control. You get this sense when you go in there. The Mission Control that I'm referring to—this is 1984, this is the same Apollo era control room that we used in the early part of the Shuttle Program. The first thing you notice is there's a lot of people, you can feel the intensity, because there's a lot of people working. But you're struck by how quiet it is. There's very little sound. That's really a false impression. Because once you put a headset and plug into the coms system, you hear a lot of sound. You hear more sound coming at you than you can handle really. You hear the crew's voice, you hear the voices of other flight controllers—controllers that are on your team, controllers that are on other teams. You have to be able to sort all that out and learn what's important and learn what's not. It blew me away when I plugged in. "Oh my gosh, how do I separate all that?"

So you start out—the flight control team is very structured and very organized. It is a team. The leaders are in what we call the front room, which is the room you see on TV. The consoles are there. Every person there is leading a team comprised of multiple individuals in what we call the back room, which is where the MPSR is, Multipurpose Support Room I think is what the acronym means. You start off as a MPSR person in the back room, and you work your way up through various certifications until you reach a point where you are able to take control of the team in the front room.

Training—you have mandatory reading materials and mandatory number of simulations that must be completed. The whole time you're doing that, the instructors and the senior flight controllers are watching you. When you feel like you're ready, and they feel like you're ready to become certified, you get a very special simulation that was designed just for you to test your ability. They call that the certification sim [simulation]. And it's a tough exam. What's really neat is you go in there and you've trained and you've learned your systems, and you get this feeling that, "Bring it on, I want to see what you got, I'm ready."

That is exactly the kind of feeling that you have to have when you're a flight controller. That you have to be prepared and confident, because what you see in Mission Control is usually really different from what you saw in the sims, but you've learned in the simulations how to solve problems, how you fit in with everything else that's going on. I had to know when mechanical systems were important and when they weren't. It was equally vital to know both those things. I had to know when to shut up and let the people with the important stuff talk.

So yes, it was a job I really enjoyed. It kept me there from '84 to the middle of 2003. I really thoroughly enjoyed it. The systems for which we had responsibility evolved, changed. We went through two really horrific tragedies that shaped us as well, the [Space Shuttle]

Challenger [STS 51-L] disaster and the [Space Shuttle] *Columbia* [STS-107] accident. It's funny how we ended up feeling really responsible for that. Because you have a feeling when you're a flight controller that, "Nothing's going to happen on my watch." You really zealously guard the crew's safety and the safety of the vehicle.

The feeling you get when you see, for example, a heater that's failing. Heater operations are something we watch. The environment of space is very hostile to a lot of things. If there's a fuel line that has to be kept warm or it'll freeze and damage the fuel line, damage the system, or have that system be unavailable, you're watching that closely. If you can see that heater is failing and tell the crew switch to another heater, and you see the backup heater start to work and the system is working again you feel like, "Wow, I just"—that little call that we were able to make helped save a multimillion-dollar piece of hardware and probably justified our salary for the year.

So yes, it was a very good feeling, very rewarding feeling, and it was a very humbling job because it was easy to make mistakes and find out we were wrong. I'm sure there are still indentation marks on the console where I pounded my fist, from when I pounded my fist and said, "That will never happen again. I will never make that mistake again."

So let's see. I was able to obtain certification and move into the front room for STS-26 in 1988 in September. That was really a great feeling. That was my first time in the front room on console, and eventually—as a flight controller the greatest responsibility for our particular discipline was during the ascent and entry phases. That was the highest level of certification you could attain, and I was able to attain that in 1990, a couple years later. So I worked orbit in the front room for the first several flights and then ascent and entry.

What happened, after *Challenger* we had several people leave the area, and we were short on flight controllers. So they had to accelerate the training of some folks. We had just certified someone in April of 1988, and that individual left. Flight controllers get hired for other positions, and he went to another position and got hired. So they approached me and they said, "Well, now it's June, and we're launching in September, and we want you to get ready and be trained to work in the front room." I said, "Wow, are you sure? That's really accelerating everything." My boss at the time told me, said, "We will make every class available to you, and we will make all the simulations available to you. But it will be up to you to be ready in three months to work in the front room." I was green as all get-out when I finally made it there, but I was able to do it. What a great feeling.

WRIGHT: What a great flight to be able to be on.

DOREMUS: Absolutely. That was so cool. And my oldest daughter was born two months later, two months after that. But yes, it was really cool. So two years later, I told you, working launch and entry. When you're working a launch, it's game on. Any time you're on console, but particularly then. At the time the director of mission operations was Gene [Eugene F.] Kranz, and of course we really looked up to him. He would sit in the viewing area right behind our console. Our mechanical console was in the very back of the flight control room. I used to call it the cheap seats. The back left. It was a great vantage point. He would sit right behind us and be listening to the voice loops. That was just a little extra incentive to do your job well, because he's right back there, and wanting him to think that you were worthy of sitting out there. That was cool.

The other thing that used to blow my mind when I was sitting there was I would look at the console hardware. This is in the 1980s and technology had advanced since the mid ’60s, but there we were looking at black-and-white screens and plots where it would plot a single character on a black-and-white screen to show us the trends in different pressures and temperatures. I would look at the buttons that we would push, and it was all ’60s technology. So on one hand you’re looking at it and saying, "You know, this stuff is old." On the other hand, you’re looking at it and you’re saying, "This is where they sat when they landed on the Moon, this is where they sat during Gemini, and what am I doing sitting here? How in the world is it possible that I’m sharing this console with those men that did that?" So that was really cool. But again, you realize, "Hey, by the way, there’s spaceflight going on." You’re able to really snap to it. So anyway, it was really fun working missions. It was great.

I really enjoyed that. We had several big problems that we had to work. One of the fun things we got to do—and I know it sounds like it’s all fun, and it all was—one of the particularly fun things that we got to do was working in-flight maintenance procedures or IFMs, and what those really were is something would break on the ship where the crew could access it, and so we would utilize the tools available onboard to develop a procedure for them to use to fix it. That was a lot of fun. That was great. We had to put an official procedure and uplink it to the crew. And sometimes it was rather complicated, like building a power cable when the refrigerator they were using for some science experiments failed, and working around that. Or building a data transfer cable for a payload data unit that was not transmitting the data, for which we had launched and gone on orbit for, properly to the ground. Fixing that was very rewarding too, being able to figure out an alternate way to save the data.

Sometimes it was really simple, like one time a Japanese Spacelab flight. For some reason, they had brought newts on orbit to study whatever one needs to see about their physiology in a space environment, and one of the poor creatures died. So what do you do with a dead newt on orbit?

WRIGHT: Not a common question we ask very often, but that's a good one to know.

DOREMUS: We were asked that question.

WRIGHT: What do you do with a dead newt?

DOREMUS: What do you do with a dead newt? We had to develop a dead newt disposal IFM. So I'm very proud to have been part of that. I actually made a change to the procedure too. Because what we did is we told them to put the newt in a Ziploc bag and double-bag it and put it in the trash. We did a drawing showing how exactly to do that. I remember changing on the drawing—there was a picture of the newt, and I remember putting a cross, an X over his eye to show that he was actually deceased to go in there.

But yes, that's some of the stuff we would do. That was it. It was really fun during STS-66 on entry. We had what looked like a problem in an APU [Auxiliary Power Unit] fuel line that could have been—APU, this is the gas turbine I talked about that burns rocket fuel. That rocket fuel that it burns is hydrazine, and there's a reason we use it for the APU. It's a really good fuel. It just packs a lot of energy per unit mass. But the very thing that makes it a good fuel makes it really bad if any of it should leak out and get onto a hot surface, because it's very flammable. It tends to react with anything it touches. It may even react with itself, it's so volatile.

We saw an indication really similar to one that had happened on STS-9 where two APUs had leaked fuel and had blown up—after landing, thank God. We saw a similar indication during STS-66 entry that there might be a fuel leak as well, and we watched that the whole time, and fortunately it ended up being just one temperature sensor indicating a decrease, which, not to get too technical, but a decrease in temperature can be because fuel is leaking onto a line and flash vaporizing in a vacuum environment. That's what the liquid will tend to do, and that takes energy away from the line and brings the temperature down.

We were watching that, and it looked awful similar to what had been seen prior to landing on STS-9. So we watched it all the way down, and worried about it all the way down, and actually shut the APU down early, but what they train you to do in Mission Control is you don't take action based on just one sensor. You make sure there's multiple sensors that agree with what you're seeing, because it could be a failure of a single piece of instrumentation. That's what it was we learned after the flight.

But again the training was absolutely right. That was the right thing to do, so we worried about it all the way down. But the crew never had to. They got to fly and not be distracted by something that did not need their attention.

WRIGHT: That sounds like one of the areas that we certainly are interested, the best practice of knowing that that's one of those elements to do. While you were thinking that, I wanted to ask you, because you had mentioned about you have to basically train to know what's important and then what's not. Are there some things you can share with us to help us gauge how you know that? How do you determine that?

DOREMUS: Yes, we saw people struggling with that. Let me define what I mean. In 1995, I became the lead for my group, and I served in that capacity until 2003. So I was lead for a group of flight controllers. It was like the player coach. Because you work missions, and you're everybody's boss, and you're responsible for their training. So we're watching people struggle, and they don't seem to be understanding too well what the big picture is and how things like that fit in. So what we did is I got the senior controllers together, and we sat down and made a set of expectations for every position. It was things that are along the lines of, "Know your system and how it fits into the big picture. Try to get inside the mind of the Flight Director. Understand what he or she needs to know at a given situation. Understand what the other controllers' priorities are." We just sat down and wrote these things down.

In the mechanical systems group, there were five positions that all required certification. So you worked your way up through all those five certifications, and we defined those expectations at each point and gave them to the people. I remember telling a young controller that we just hired, I'd say, "Here are the answers in the back of the book like you have in your textbook. Read these and understand these."

It helped. It really did. Why not give them the answers, because they will face the exam. I really did not enjoy the part of the job where I had to bring someone to my office. Not everybody was able to be certified, and when you tell someone, "I'm sorry, you're not cut out to be a flight controller, you're going to need to find another job," that is no fun. You think of the investment we've made in this individual to get them to the point where we try to certify them, and a failure there is very costly. The resources over there are not so great to where that kind of thing needs to happen very often. It's very important that the people who are brought in are good ones as well.

So giving them the expectations really helped. We did another thing, trying to accelerate training, because you want to train people effectively. They have to be ready. You set the bar, and the bar is there, and you do not lower the bar, because we feel like where we have set the bar in terms of aptitude, capability, and what a person can be able to do when they're on console—that's a line in the sand we do not cross. We don't send someone up there who's unable to do the job the right way. So given that how do you get someone trained effectively if they're struggling?

We sat down and struggled with this because we saw folks floundering a little bit. We were wondering is it because of the way colleges are training these days. We wondered a lot of things. We decided that it was not going to be because of something we were doing in training that was ineffective. So we reviewed our training process. I took a look at the baseball teams. They had a big article in the paper about how the [Houston] Astros [baseball franchise] minor league system, they'd redone their training, and how they had individualized training at every level. This is an example of a best practice. We saw that, and I brought the senior controllers together and gave them each a copy of the article, and said, "Is this something we could apply to flight controller training?" Why not? Because you're a ballplayer, you want to move from class A to AA, AAA, all the way to the big leagues.

There were some things we saw there that we applied, and we changed the way we trained to provide a lot more. We set up classes that senior controllers taught just on specific systems to give to the folks. We set up little mini-sims led by a senior flight controller to help these folks come along. We gave them their expectations as well. So we really, I think, made a significant contribution to training. It really improved things. I think the people coming out of there were way better trained than I was back in the ’80s.

WRIGHT: What do you think based on your almost 20 years there, and then you just talked about revising the training—what do you think is going to be needed to equip and train the next group coming in?

DOREMUS: For controllers, I think they’re going to need to take a real hard look at Shuttle. But I think the way the Shuttle missions are conducted is a lot like the Apollo missions. And it is a two-week period of intense activity and round the clock support. The new program will be—if we do a lunar expedition mission and we bring the crew right back, that’s going to be very similar to a Shuttle or Apollo mission. But I think what we have planned for the lunar missions and for the Mars missions is going to be a whole lot longer duration. Mars, it takes a year almost just to get there, and you want to stay there that long, and then another eight months to a year to get back.

So I think they need to look at what we did with the understanding that it does not apply completely to the nature of the missions they’re going to be conducting. Look at the best practices, but if the mission you’re working is going to last three years, what level of certification do you need for the beginning? How do you manage the entire mission? How do you manage the people? People working in Mission Control, you work shift work, it wears you down. I’d had it with shift work, especially working nightshift, by the time I left. When you’re 24, it’s not that big a deal. When you’re 43—

WRIGHT: Start to feel it.

DOREMUS: Yes, a little bit, yes, and keeping your kids from preventing you from sleeping during the day when you have to go in at night and things like that. So to answer your question, look at what Shuttle did, but look at it with a critical eye, because it isn't all going to apply. We should really look at our friends in the [International] Space Station world. They're doing things there where they're managing the people quite effectively. We could probably take out Mission Control, the building, and be able to manage a mission at another facility if we still had the people who could sit at the console. They're such a valuable resource, and we've got to take care of the folks that support the missions. They're vital, and they need to have something that keeps them interested and motivated, and you have to maintain their training. Are they going to be as sharp three years from now? Do they need different skill sets during each phase of the mission? Do you do that with different people? Do you have enough people to do that? It's going to be a real interesting challenge for how they do that.

WRIGHT: The teamwork that you talked about certainly infers a definite level of trust between the management and the team members. How is that built, and how do you maintain that level of trust?

DOREMUS: It's easy to say in the Control Center, "You have to trust your folks on your other teams." You have three shifts or sometimes four. You can't be there 24/7. They have to monitor the systems while you're not there, and they have to communicate to you effectively what they've seen and what it means. You have to do the same for your team members. So there's an hour period, and there are three of them each day, in which the oncoming team receives a handover from the offgoing team, and that has to be done right. We developed a checklist for how to do that. So part of it is, "My buddy has told me everything I need to know, and I therefore trust him."

So that's for the folks that are on the mechanical team. But what about the people looking at electrical or propulsion or the robotics person or the other? A big part of that is respect. I know you are an expert in your system, and I trust you to say that, and I understand you know that I have the expertise in my system. Conveying respect to one another, avoiding the jealousies about who owns what. You get that. There's human beings over there sitting there, you get those little things going on.

So mutual respect between team members, that's really good. The Flight Director sets such a critical tone. If the Flight Director is listening to people and respecting their ability and their value, the teamwork just flows from that. Really, from having observed probably 20 to 30 different Flight Directors operate, I got to see who did a good job there and who struggled. I would take mental notes on what I thought the aspects were of a good leader. One thing that is huge, a good leader needs to be decisive. There are plenty of jobs down at the Waffle House for people that can't decide. Again, the needs of the program define that.

A good leader is respectful of the people on the team and treats them with respect. It sounds so easy to do, but the third aspect of a good leader is a leader has to be able to communicate to the team, "We're going to make it through this, even though it's difficult." An ineffective leader will react emotionally, and people lose confidence in their ability to be objective. A good leader will be there and be a calming influence or a steadying influence or a motivating influence towards getting the whole team to accomplish the mission. So giving you examples of what I took from there and try to apply here.

By here I mean the Space Shuttle Program. I've had to head technical panels here, and so I've tried to have people treat one another with respect, and treat them with respect. And to get people—if we have a difficult technical issue that we have to review to say, "Hey, this is going to be hard, but we're going to get through this. This is not something we can't handle." I'm trying to give you stuff that's helpful.

WRIGHT: It is. A lot of what you've had to do in the flight control room and now, you've dealt with risk. Are there some lessons and some aspects of risk management or risk mitigation that you could pass on?

DOREMUS: Yes, I could. That's been one of the things I've enjoyed being in the program S&MA [Safety and Mission Assurance] office, part of our responsibility is risk management. What a great tool risk management is for the program manager. I did not realize that. In a way, everyone intuitively conducts risk trades. When you're going to pull out into traffic, you're doing a trade on how good is my vehicle versus how fast is that car coming, and what is the road, and things like that. When you see a yellow light you do a risk trade, "Should I punch it, should I slow down, is there one of those cameras at this intersection?" Those kinds of things.

We talk risk a lot in the Shuttle Program. We talk about hazard reports. They are a rigorous assessment of a hazard that could affect the safety of the crew or the vehicle that gets compiled in a report and approved by the program manager. We look at items called critical items lists, or CILs, and those are areas in the design that don't meet our requirements—usually for really good reasons. Like we require there to be redundancy in everything, and some things you can only have one of certain pieces of hardware.

So they don't meet our requirements for very good reasons, and we say in the CIL why they don't meet our requirements. And why even though they don't meet our requirements, it's still a good design. We have that all documented. So you have a hazard, you have a CIL, we have these analyses that the people that do I guess a bag of bones and they throw them out, and it comes up with numbers on how probable a failure is. We have those. Probability of an issue, of a bad thing occurring. We do a lot of work with that. We have folks that are really good at that. When I say bag of bones, I'm only saying it because I'm not smart enough to do that sort of thing, but we have folks that are.

We have a risk system where we describe risks. So we have a hazard, as I mentioned before. There is a risk associated with that bad thing happening to us. For example, the debris coming off the external tank and striking the Orbiter, that's a risk. Lightning striking the vehicle and causing damage that we don't find out about until in flight, that's a risk. It represents a risk or a hazard. So a hazard, there's a risk associated with it.

The design problems I told you about, though they don't meet our requirements, so there's a little bit of a risk associated with that. Then there are these probabilities that it's a one-in-X likelihood of a bad thing happening. It may be one of those hazards we talked about. It may not be. Then we have a risk system that talks about just risks. We have to define a risk, and there's a risk in our risk system talking about debris hitting the Orbiter. There are risks having to do with lightning. There's a little bit of double bookkeeping, but it's a different perspective on each one. So what I have learned—I'm sorry this is taking a long time to answer the question.

WRIGHT: It's a pretty difficult subject.

DOREMUS: It is, and I hope I'm explaining it at an understandable level because I'm trying to. I usually practice on my kids. With teenagers, if you can keep their attention—so the idea I had, if you want to call it that, was I should probably be comparing hazards and CILs in this risk system that I have, and these probabilities, and comparing between the two. So the program manager, when he has to decide where to spend his money, which is a limited resource—"Does PRA [Probabilistic Risk Assessment] tell me one thing and the hazard tell me another? Do they agree? Well, why don't they agree? I have a CIL there, but the hazard says it's probably okay. But my probability says it's very likely to happen. Therefore do I want to spend money on preventing foam from coming off the External Tank, or do I want to spend it somewhere else? Do I want to spend money on lightning protection?"

The thing that seemed analogous to me was a flight controller sitting in Mission Control will look at a temperature and a pressure or a voltage measurement, and he or she will be trained to understand what those mean. It won't be just looking at one temperature measurement. Like I told you about that fuel line. I can't look at just one little temperature. I was looking at the whole fuel line, the whole system, and seeing if there was a sign of a leak. Well, can John [P. Shannon], the [Space Shuttle] Program Manager, or [N.] Wayne [Hale], look at the whole system of risks like a controller, and there's unlike components, and compare across the two and draw conclusions about where to spend his money?

I think we're just now understanding how to do that in the Shuttle Program. Which is great, because we've got ten flights, and we can do it, and we have limited resources, and maybe we can serve the agency by figuring out ways to do that.

So really to summarize it, can you compare the ways that risks are presented to a program manager—and they're communicated and presented in different ways—and look across those different ways and bring trends or draw conclusions from the differences or the similarities about how to spend your money? That's what we're trying to develop here in our office. Again, I'm not claiming we have this process nailed down. We're really learning how to do it. I think also I've seen the program start to look at risk management as a useful tool, where the whole program is buying into we can look at this risk management system and how risks are elevated and how things get communicated to the program manager.

So check back in a year and see what we've learned, because we are learning right now. That's one thing that I like about the job, is we can still learn. We're going to be looking at shutting the program down, which hasn't happened in a while to a major program like this. We'd have to go back to Apollo to see the last time a really significant program was shut down. We got to do it right and prepare for the gap that's going to be going on.

One thing we are going to be trying to do is find efficiencies in how we're doing things with our limited resources. All those items I described to you, CILs, hazards, risk management—those all take people to do and other infrastructure resources. Can we do them more efficiently? We're going to be forced to do it more efficiently as we're winding the program down. So because of the nature of the challenge we've been presented we may—not we may—we will have the opportunity to find efficient ways of doing things that can benefit the rest of the agency. So in a way, you can look at what we're doing in the Shuttle Program now, and you look at it from that aspect and say, "Okay, they got a chance to really figure out how to do things efficiently, because they have to."

The other thing you look at is, "Boy, what they're doing is pretty cool." Finishing building Space Station. This has been since '04—this has been really a challenging time. Some of the missions. Now instead of as a flight controller, I sit in the Mission Management Team [MMT]. What we're doing is amazing. We had another APU fuel problem on STS-121, and I was asked to lead a team to help assess the risk trades associated with how to operate that APU on entry with a potential fuel leak. Thank goodness, it was not a fuel leak, but a leak in the nitrogen system used to pressurize the fuel. But we were prepared if it had been.

We had taken the right steps, and it was fun getting to work with the flight control guys again and determine operationally what we could do in the event that we did have a fuel leak, and we came up with a really good set of risk trades. You could do A, you could do B, here are the implications. It was in this case A, B, C, or D. Here are the implications of each. So I was able to pull a team together to go through those with the experts and then present that to the MMT. The MMT made the right decision because they had a good view of what the trades were involved. Just like you know coming into that intersection if it's got a camera or not and how pale green or bright yellow the light is going in. If you have a good understanding of it, it should be an easy decision, unless you're not a logical reasonable person.

WRIGHT: That was a very good explanation. So thank you for that.

DOREMUS: Yes, it's been intense in the Mission Management Team. We're really sensitive to anything that could damage the heat shield, for obvious reasons. I'm going to jump back to 2003 [*Columbia* accident]. The mechanical systems team—boy, what an unusual time that was. We had seen the video of the foam striking the wing, and at that point in 2003 there was no instrumentation that the flight control team could look at to tell what had happened to the wing. Really it was a matter of the engineering evaluation team looking at that, determining the magnitude of the impact and the extent of the resulting damage. It was up to them to do that. Our flight control team would deal then—take whatever steps were necessary based on the assessment of the engineering team. The engineering team says, "That's a bad hole in the wing," flight control team would do what they had to do.

Our guys on console were therefore largely unaware of some of the debates that were going on behind the scenes relative to there being a problem with the wing or not. Some folks actually got e-mailed some of the presentations. But again, on console, you don't really pay that much attention to e-mail, because you got plenty to do, and you got the mission in front of you, and if you have time you read e-mail—but generally you don't have time. But they did actually have some folks that had done some simulations and thought, "Well, if the *Columbia*'s left wing was actually damaged, it could affect the hardware that's inside the wing well, including the main landing gear area."

Some of the folks who have responsibility in engineering for dealing with main landing gear actually did some simulations to say, "Hey, if we had a burn-through, and it affected the tires, would we be able to do a safe landing if one of the tires failed and the other one did not?" You have two tires on each main landing gear. They just sent an e-mail to the guys on console and said, "Hey, by the way, we looked at this, and we think if one tire failed you stand a reasonable chance of"—and there's four main gear tires, there's two on each side. The question was if one of the tires failed, would the other tire support rollout and landing. If both tires fail on one side, then the Orbiter is going to pivot on that. It wouldn't be a good situation.

So they sent that information to the guys on the flight control team and said, "Hey, we think probably you'll make it if you've lost one of the tires." The guys on the flight control team saw that and talked about, "Well, if you had damage bad enough to get into the wheel well and damage a tire, that failed tire is going to be the least of your problems." So they sent a couple messages around saying, "I think this is what we would see, burn-through and temperatures going up, and eventually loss of the vehicle." They described what was really going to happen, because they know that. Again, these folks from engineering were just trying to be helpful, but it really wasn't useful at all.

But what the guys on console had heard was that the Mission Management Team had looked at the failure and determined that the impact was not going to cause burn-through. So in the minds of the guys on console, everything was going to work. They just did this speculative, "If it really were bad, what would it look like," and they put that down in some e-mails that unfortunately got released later on to the press.

So imagine you're sitting console and you've been through this in your mind, what would it look like, and then they saw that scenario unfolding in front of them. It was just devastating to the team. The first folks who noticed the tire pressure problems and saw some of the alarms were our guys on console that had been involved in that e-mail. So for our whole team, it was really difficult, I'll just say. We ended up with media attention because those e-mails got released later on. That was along the lines of, "Why didn't you share your concerns?" when in fact there were no concerns, it was just an understanding of if there really was an issue what would have happened.

It's funny, the way those things affect you. Between *Challenger* and *Columbia*, when I went into the Control Center and talked to those folks right after within an hour of the incident, all the group leads came in and were sitting with their guys who were just in shock, and I saw them. All they really knew how to do was fall back on their training, pull out the procedure, and start gathering the data that they needed to do. That somehow gave them—I guess just to sit there and not do anything was too hard. They were able to pull together as much information and data as they could. Then we were very deeply involved after that in all of the investigation to try to determine what had actually happened. But the observation I had was how they were falling back on their training.

I actually had three brand new people in there who were OJT-ing, observing their first landing, and each one of those folks is now a certified console operator who has had a successful run since then and is now a veteran of several flights. But yes, that was very hard. Again yes, that same—you tend to blame yourself, "What could you have done, what could you have done." And really again the folks on console, that was not—shouldn't think that way, but you tend to do that. May be just human nature, I don't know.

So I brought that up just to let you know the way people react in that kind of situation. If you're really well trained, it helps you quite a bit to have something to do and to focus on it. Those of us who had been through *Challenger* were able to tell the folks, "We'll get through this." Like what I said, a manager has to be able to do is say, "We're going to get through this. This is going to be hard, but you got to be strong right now, and you got to focus on the investigation and moving forward to the next step."

WRIGHT: What do you feel that you'd pass on as probably the best or maybe the hardest lesson that you've ever had to learn during your years here?

DOREMUS: Wow. I think it would be being able to persevere through adversity. Because when you're in a really great job—did I mention that this is a pretty cool job? When you're in a really cool job, there are a lot of really cool things you get to do. You get to meet some of the finest people that you'll ever want to meet, the other controllers. And these outstanding folks, the astronauts, you get to meet them and work for them sometimes now like I've done the last three years. You get to go look at hardware, you get to crawl around inside the vehicle. For me, when I do that, it's like time stands still. I'm enjoying that so much when I'm out at the Cape [Canaveral, Florida] or somewhere else, you're doing that.

You get to sit on console, and one of the greatest feelings in the world is sitting on console and the crew is asleep, everything's running fine, and you know it is, because your team is on duty and it's all running well. Sometimes at night you're on a graveyard shift, and they'll run the cameras from the payload bay down at the ground. And you'll be looking at the tail of the Orbiter silhouetted against the Earth or against the night sky, and it's a really peaceful feeling. You'll watch South America or Africa going underneath you, and you'll watch that and you'll be looking at your data and you'll know things are running well, we're ready. It's a great feeling. So you get to do stuff in a job that is just really cool. So that's why I say cool job, and I could go on.

With a great job comes the potential for great heartache as well, and great risk—that goes along with great reward. It's hard to describe to new people coming on, but it is a real part of the job. Your actions could have ultimate consequences. When you make a mistake in there, you feel horrible. I've done my share. You make a mistake, headlines happen. I used to show folks a headline from a paper, from the old *Houston Post*, from a mistake I'd made one time. You do. So the hardest lesson is that you're going to really enjoy the benefits of the job and they are sublime, but sitting there in the office and having someone come in and say, "*Challenger* just blew up," or getting the phone call at home on a Saturday morning about *Columbia* and rushing in to be there with the folks, or dealing with a mistake you made and the bad things you feel. You can get through that, but that is a part of the job. So the hardest lesson is how to persevere through that and continue, because we're going to encounter obstacles like that if we try to go back to the Moon and when we try to go to Mars. We've had big roadblocks in Shuttle.

What happened last year during the summer? We had a hole in the heat shield again that the astronaut had to go repair. We had major computer problems on Station. That was Apollo 13 again, and we handled it. But it was pretty sporty while we did that. We thought the very next flight, [STS-]118, that we might have a hole in the heat shield again, and, "Do we go out and fix it or not?" These are really tough problems, and we're going to struggle with that again. We may get another hailstorm on a tank and figure out what to do. I had my whole family out to watch STS-122 launch in December. We didn't launch.

Dealing with the adversity that you face as a consequence of being in a really neat job is the thing. You can train people to understand the systems. You can train people to solve problems, although they don't come out of college necessarily knowing how to do that. But dealing with adversity with the hardest part. You remember the feeling. I still remember driving—were you all around during *Challenger*? I remember driving off site that day and seeing all the flags at half-mast. I lost it. I'd only been here a year and three months. Then *Columbia* was so much deeper. That's part of the job. Having reporters come to the house, and having your teenage son answer the door, and there's a *New York Times* fellow wanting to talk to you. That's as much a part of the job as getting to go to Kennedy Space Center [Florida] and see the launch. But the other part of the lesson is the benefits of the job far outweigh the difficulties and the trials.

WRIGHT: That's good, and it might be a good place for us to stop.

[End of interview]