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MATTHEW R. ABBOTT
INTERVIEWED BY JENNIFER ROSS-NAZZAL
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ROSS-NAZZAL: Today is July 23, 2009. This interview with Matt Abbott is being conducted in Houston for the JSC Oral History Project. The interviewer is Jennifer Ross-Nazzal, assisted by Rebecca Wright. Mr. Abbott was the lead Shuttle flight director for STS-124. He's here to talk about planning, training, and flying this mission. Thanks again for joining us.

ABBOTT: You're welcome.

ROSS-NAZZAL: Certainly appreciate it. I'd like to start by asking you what's the role of a lead Shuttle flight director?

ABBOTT: Through the history of the Shuttle Program, the Mission Operations Directorate and the flight control team led by the flight directors is really responsible for executing the mission. The Space Shuttle Program Office, the group that actually defines what our mission objectives are going to be from an agency level on down, will lay out a series of objectives to accomplish during the mission. It's up to the Mission Operations Directorate, along with the flight crews, of course (the astronauts), to go and execute that mission. So [as] the lead Shuttle flight director, my job was to integrate all those functions, the planning, and the training to a certain extent (I was a participant in the training, and also [helped] to make sure that the right training was being

done), and then actually executing the mission from the standpoint of the Space Shuttle and the Space Shuttle Program.

Most of our missions right now are to the Space Station. So there's a lead Space Station flight director and a lead Shuttle flight director. We work together to accomplish the mission, since our primary objectives on this mission were to do Space Station assembly and outfitting and resupply. Getting back to the program objectives, they will lay those things out for us and say, "These are the things that we want to accomplish on this mission."

As with any big project, you can break it down into smaller pieces, and there's only so many hours in the day, and so many hands and eyes to be able to accomplish tasks, and so many people on board to be able to do things. So we have to lay all those things out into a timeline that the astronauts and the flight control teams are able to execute without any risk to the astronauts, to the Space Shuttle, or Space Station, and really within a lot of constraints that we do to make sure people aren't overworked and working 24 hours a day. It's a big puzzle that has to be put together to make it all fit.

ROSS-NAZZAL: When did you start working on this mission?

ABBOTT: I was assigned to STS-124—I'm trying to remember—I think it was about a year before the flight. I was also the lead Shuttle flight director for the STS-118 mission. I finished that mission and went right into the planning and preparation for STS-124. I got right back from one lead assignment to the next. As the lead flight director, I was the focal point on the Space Shuttle side for all that integration of all those activities together. Of course, there's a team of

flight directors on both the Space Shuttle and Space Station in both of those control rooms that will rotate around the clock.

There was an ascent flight director that worked the launch, an entry flight director that worked the landing, and then a team of 3 or sometimes 4 flight directors including myself that would rotate through the orbit phase of the mission. I say 4 sometimes, because with longer missions we like to try to avoid working people more than 12 days in a row just to not really burn them out and give them a little bit of a break in the middle of the mission. If we're faced with a situation like that, we'll insert a sub [substitute] for a shift or two and break things up for those people. So my job, again, is not only leading that flight control team, but also this team of flight directors in that mission execution.

ROSS-NAZZAL: Can you tell us about your role in planning?

ABBOTT: Yes. The planning job is really what it's all about. One of the things that we demonstrated with this mission is if things are working right, if the hardware on the Space Shuttle and Space Station are working the way that it's designed to work—we all know whether it's at home or your car there's little things that can go wrong, office computers, things like that. But it really comes down to putting a really solid plan together that allows everything to happen in a reasonable amount of time, without having too little time to do things, or without having long periods of time where people are sitting around doing nothing when they could be getting work done.

I know that you spoke with Terry [L. Clancy] and Gail [A. Hansen], our lead flight activities team. They're the ones who are really doing a lot of the legwork and a lot of the real

nuts and bolts, putting the plan together. As a flight director, it's my job to help make sure that they're getting everything they need from the rest of the flight control team, from the other flight controllers that are responsible for Space Shuttle electrical systems or communication systems, thermal control systems, all the different things that have to be managed throughout the mission. Then on top of that, of course, is the reason we're doing the mission, and all those mission activities to actually assemble the Space Station and do the transferring of supplies and things like that.

All those things take time. Really my role in that is to work with Annette [P. Hasbrook] and her Space Station flight control team to make sure everyone's inputs have been put into the system, that the planning teams can then work on that and find a way that fits things together within all the constraints. The astronauts will sleep for eight hours a day. They have to have time to wake up and have breakfast. They have to have time to wind down before they go to bed. Need to make sure that they eat lunch and things like that. The things that you need to do just that you don't really think about in day-to-day life. When you're faced with a mission of 11 or 12 days, you have to get everything done in that time. It's really important to have all that laid out.

So the flight directors are really responsible for making sure that all the team members from the flight control team, the program office, the engineering teams that are responsible for the hardware, and in the case of STS-124, the Japanese flight control team and all the Japanese hardware that was flying for their aerospace agency, needed to come together so that the planners could do their jobs and put together a plan.

ROSS-NAZZAL: One of the things I understand that you work on in order to prepare for a flight are flight rules. That's something we didn't really talk with anyone about. Can you give an example of a flight-specific rule? I understand that you have a generic book full of those flight rules.

ABBOTT: Sure. Let's see if I can think of a good example.

ROSS-NAZZAL: Or maybe how they're written? Maybe that would be better?

ABBOTT: Sure. The purpose of flight rules is really to make decisions ahead of time about things that might go wrong—anomalies, things that could happen. Actually, let me back up a little bit. There are cases where there's flight rules that describe how we're going to operate nominally. But the best examples are really the ones where you're going to encounter an off-nominal situation. Some sort of problem is going to come up [and] it may not be clear-cut in terms of the response that you're going to make when that happens.

I'll give you an example here in a minute. But just the big picture. With flight rules, we can argue for weeks on end or months or what have you, maybe not continuously, but over time, where we can talk about different ways to handle a particular failure and say, "If this happens, we want to—." We come up with a bunch of options and talk about the different ones, which one might be best for the situation that we're in. Then once we arrive at a decision, we write that down, and that becomes the flight rule. Basically says, "If this happens, this is the action that will be taken." The whole idea is to minimize the amount of real-time rationalization. If you

have that failure you don't want to sit there and have the whole team come to a standstill and say, "Oh, well, we didn't think of that, what do we do about this now?"

You want to have those discussions ahead of time. If they're written right, if they're written properly, documented properly, and understood by the whole team—which is something that we expect of the flight control team members, is to know why they're written the way they are—then when something happens in real time, we know the flight rule. As we discussed, [it] says to do this, and that's the course of action that we'll take.

Of course, having said that, there always can be exceptions. That's why it's important that the people who are responsible know why it was written the way it is. It may be that the way you got into the situation doesn't really apply. So maybe you do need to take a different action. [The] whole idea is to talk about it as much as possible beforehand so that you can figure out a course of action. I'm trying to think of a good example.

On this mission, we had a very unique situation with the inspection boom [Orbiter Boom Sensor System] for the Space Shuttle. As you know, since the [Space Shuttle] *Columbia* accident [STS-107], we've had this long 50-foot boom that we attach to the end of the robot arm. We can wave it around pretty much all over the vehicle and inspect it. There's a laser system and some optical cameras. Downlink all that information to engineers on the ground and make sure that the heat shield, the Thermal Protection System on the Shuttle, is in good shape. On this particular mission—and this ties back to the planning too, in order to carry up the big Japanese Experiment Module [JEM], their pressurized module, in the payload bay, we needed to not carry the boom with us, the inspection boom, because of weight and clearances and things like that.

The decision was made at the program level, in conjunction with inputs from mission operations, to leave the boom on board the Space Station on the flight before. So there had to be

brackets installed on the outside of the Space Station, which incidentally were installed on the other flight that I was lead for. Then the flight prior to ours, they left the boom up there. They installed it in the brackets. They hooked up a power cord—it had some heaters on it—so it wouldn't freeze up there. Then we would go, and one of the first things that we needed to do was go get the boom back. It's funny, I'd tell Annette sometimes when we were in discussions about other things that were really Space Station-centric, I would say, "Hey, I just want my boom back. After that, I'll be happy." I used to joke with her about that.

But we had to go retrieve the boom. To do that you had to have the astronauts go outside and do a spacewalk to unhook the boom, unhook the power cable, and grab it with the robot arm. Actually, it had to be grabbed by the other robot arm and then handed off from one robot arm to the other. So it was a very complicated series of events that had to happen.

Throughout all that, we had to have flight rules that said, "Well, if we get the power disconnected, we have only a certain amount of time before we need to get it grabbed with the Shuttle arm where it can plug in again and get heater power before it would freeze." There was a lot of analysis done by the engineering community to determine how much time we had to do that. So we had flight rules that said, "This has to happen within this length of time. Or we will do—." There were different options for what we could do. We could try to put it back in the cradle that it was taken out of. We could hook the power cable up again while we were thinking about it. There were a whole lot of interconnected decisions that could be made based on that that had to be made.

At some point, there was a series of events if you got to a certain point where we said, "You know what? There's nothing we can do to get it back to a place where we have power." So there's another example of a flight rule that said, "When we got to that point we are

continuing with the transfer, and we'll troubleshoot on the Shuttle side once we get it back attached to the Shuttle arm."

So I hope that helps as an example of a flight rule. It's a lot of complicated things having to go right, and any one of those things going wrong could cause you to branch out into a couple of different decisions. Sometimes it can be hard to make a decision because you don't necessarily know exactly what's going to happen. If we take power away from the boom, will it survive if it drops to a certain temperature and then is warmed back up? Can you go a little, 5 more degrees colder, 10 degrees colder, 20 degrees colder? If you only go there for a few minutes and then come back up, is that okay? Are you going to crack circuit boards and things like that? So there's analysis done.

Then there's judgment that has to be applied on top of that to be able to make a decision that everyone will agree to preflight. That's another difficult challenge too. Some of the analysis can be very conservative, and rightly so, because we want to make sure that we don't break the hardware. At the same time, sometimes that conservatism can be so extensive that it leaves us very little flexibility in terms of the operation. So there's a tradeoff there. Can we shave off a little of that conservatism and give us a little bit more room to work with? Because if we have a little more room to work, we might be able to fix the problem and be very sure that we can keep the hardware safe, as opposed to taking drastic action on something that maybe has a little bit of extra pad in it that it might not really need. It's a whole lot of tradeoffs like that need to be made.

ROSS-NAZZAL: It sounds complicated. All this rationale is then put into this book? Is that my understanding?

ABBOTT: Yes. We have a bunch of generic flight rules for Space Shuttle and generic Space Station flight rules. We have a book of generic Shuttle-Station flight rules that are for the joint mission when we're docked together. Then there's a mission-specific book of flight rules which is broken into those three categories as well; Shuttle only, Station only, and joint ones, that [are] really just for that specific mission. We try to keep that one as small as we can. We try to make things as generic as possible, just to keep things "simple."

ROSS-NAZZAL: Tell us about your relationship with the crew of STS-124 and how closely you might have worked with them.

ABBOTT: That's a great question, because we do establish a really good working relationship with the crew, especially the lead flight directors. On this crew, several of them I had worked with before. Several of them had worked as CapComs, the Capsule Communicator, the spacecraft communicator position in Mission Control, on the Space Station side. I'd worked with several of them very closely there. A couple of them got to be friends through that, [others] through some of the other activities at work.

Ken [Kenneth T.] Ham is someone [I had] gotten to be really good friends [with] before that. So it was great to be working with him again. I missed an opportunity to go on their NOLS [National Outdoor Leadership School] trip.

ROSS-NAZZAL: Was that to Alaska?

ABBOTT: That was the Alaska trip, yes. Unfortunately, because of the timing with my work on the mission I mentioned—I was STS-118 lead also—I had to be at the Cape [Canaveral, Florida] for the Flight Readiness Review for that mission when the NOLS trip was happening. So I missed the opportunity there. I know Annette got to go on that. I was really sorry I did. I still had and continued to develop a great relationship with the crew, but I've always regretted not being able to go on that trip too, because that's something that really cements that bond.

But over time, between the simulations and all the planning and working through issues, get-togethers after work, there's a lot of opportunities to build that team. It's very, very important, especially for the lead flight directors and some of the lead flight controllers, to develop really a friendship and camaraderie with the crew. It's one big team. That's really the way we look at it.

The astronauts, they're the ones who have their hands on and are doing the actual work. To be part of that team and this huge ground team that's supporting all that, the more of that kind of bond that you can develop, the more successful the mission will be, because you develop a feel for how the other people are working. Or when things are going a certain way, you might have a good understanding of what might be going through their mind, or how they're responding to something, or maybe it's something because of discussions that happened preflight or in training that you think this might be really frustrating to them. It can help us on the ground to provide them with the right information to be able to work through it.

We have an opportunity, too, these days with email, to communicate by email on the "How's it going" kind of stuff which is good, because it gives you that friendship bond that really makes a big difference.

ROSS-NAZZAL: You mentioned that NOLS trip. Is that something that each mission tries to do with the flight control team and the crew?

ABBOTT: The NOLS trip is really a flight crew trip. I think just about every mission does a NOLS trip. Recently the lead flight directors have been invited as well. So it's really just the two, the Shuttle and Station leads, or if they're not able to make it, then sometimes there'll be a substitute other flight director that will go on that. Really it's a team building thing, not only as a specific team, but also overall. There's overall leadership skills and things that develop out of that. Not just for the mission in particular, but for everything else in one's career and life really. It's really a unique opportunity. I was sorry I didn't get to go.

ROSS-NAZZAL: I'm sure Alaska would have been nice that time of year. Let's turn to training. You're head of training now, you mentioned. Can you talk to us about the different types of training that flight controllers and the crews participated in? The integrated and the standalone training?

ABBOTT: There's a lot of training that's done, of course, for the crew. They need to understand every aspect of their spacecraft and the spacecraft that they're going to be visiting—in the case of the Shuttle flying up to Station—and all the hardware, whether it's experiments or the assembly hardware. They need to really get their hands on that and understand it, because if something doesn't quite fit right or doesn't work right on orbit, they're the ones who are there on site. They've got their eyes and hands on it and they can manipulate it. So they need to

understand it well enough to be able to communicate that information to the teams on the ground who have all the experts, even down to the people who built it.

There's a lot of standalone training that goes on. There's a lot of trips that the crews take to do things. There's things called bench reviews, where they'll get a group of some of the equipment that'll be flying, and they'll be able to pick it up and ask questions about it and get briefings on it. There are familiarization trips. I spent a couple of trips down at the Cape looking at the Japanese module, the JEM pressurized module, down there to be able to get a look at it, to see where all the connections are, especially for the spacewalking crew. They need to really have it in their minds where everything is. You see it on paper, and it's like these little pictures of stuff. When you see this 40 or 50 foot-long module, 15 foot diameter, with all these cables and ports and things all over it, and you realize that [a] couple of your friends are going to be crawling around outside there hooking things up and configuring it all after it's installed, it's very important for them to have that kind of understanding of the hardware.

Plus they can also propose changes, because they know in their training, in some of the training that's done in the Neutral Buoyancy Lab, over in the big pool, to understand what they'll have to do. They can suggest changes to the engineers to say, "Hey, can you move this over here so that I can have better access to what I'm going to need access to? Is there a way to maybe mark this in a certain way that it's a little bit easier to spot?" There's a lot of things that they can do by doing those familiarization trips.

The training itself is pretty intense. It covers all aspects of the mission. The crew will do standalone training with a specific system or specific piece of hardware. They'll do team-based training with their robotics or Extravehicular Activity [EVA], the spacewalk instructors and flight controllers. They'll do some stuff focused on that team.

Then you have the integrated training that goes on. That's the astronauts over in their Shuttle and Station simulators. The flight control team, both Station and Shuttle flight control teams in their respective flight control rooms. It's all tied together with a simulator that simulates the rest of the world, the rest of the universe. So it's really remarkable. The integrated sims [simulations], it looks and feels exactly like real life, exactly like real life for the flight control team. Of course the astronauts over in their simulator are in a one-G environment, and it's a little different there. But even so, the hardware that they're manipulating in many cases is very similar to what they're flying.

But to a control center team, it looks and feels just like the real thing, with one exception, and that's that in real life things aren't breaking as much as they do in simulations. There's a team of instructors. On the Shuttle side, we call the lead the SimSup, the Simulation Supervisor. There's a Station Training Lead, the STL, who is the Station counterpart to the SimSup. There's also a team lead that's named for the Shuttle mission simulator that follows the crew and guides the crew through all their training in the Shuttle mission simulator. But those leadership positions guide teams of instructors that, for the integrated training, will put scripts together. Say we're simulating a particular day of the mission that has robotics, transferring that boom. We're going to simulate the astronauts doing their spacewalk. There's some other activities going on at the same time.

So you have this portion of the timeline that we talked about before that you're going to simulate. We're trying to train everyone. We want to throw malfunctions at people, but you don't want to go too far to where the malfunctions are so prevalent or so severe that you basically can't finish what you're doing.

ROSS-NAZZAL: You don't want to kill the crew, in other words.

ABBOTT: Right, exactly, that's exactly right. [And[you don't want to say, "Well, we've got to cancel this spacewalk, and it means we're done for the day and we're going to have to replan the whole rest of the mission." If you do that two hours into a simulation, you have now wasted everyone's time, because [then it becomes a planning exercise and] there's not really anything meaningful for them to do [in real-time]. So you want to give them enough work.

This is something that the training team does, is script these things in a way that really stresses the communication within the flight control team and with the other flight control team—Station to Shuttle—and with the crew, with the astronauts. You want to get people talking. You want people to try to work together to figure out how to get out of this bind. We mentioned flight rules before. One flight rule, one situation is relatively easy to work through. When you have 3 or 4 different things going on across the vehicle, and, "Oh by the way, the response to this one per our flight rules is this, but that's in direct conflict with what I'm trying to do over on some other aspect of that day," you can have 3 or 4 of those things all conflicting with each other, to where if you pick an action on one you now shoot down everything else that's going on. It's a real tightrope to figure out. It's actually an awful lot of fun. It's stressful, but to me, and I think for most of the teams, the astronauts, the flight control teams, it's really fun.

You come out of a well-scripted simulation, and you feel like you've been through the wringer, but you know you got the job done in the end and things went the right way. Sometimes not. Sometimes you have one that's a total disaster. Then you think about, "Well, I could have done this." We do debrief them afterwards. We'll have a debrief with the whole team and talk through the major failures and talk through how we work together as a team.

That's facilitated by the flight directors who are on console, with the crew's input. The training team joins in too, so they can throw things in and talk about things and ask questions like, "Well why didn't you do this instead of that?" and have those discussions right away after the simulation.

So there's a plan that we lay out of simulations. Earlier in the Shuttle Program, there were lots and lots of simulations going on all the time. There really still are, but for any given mission, we try not to spend too much time on those, because while it's excellent training, there are so many other missions and activities that are clamoring for the facilities that we have to try to make all these things fit together. You may have three or four missions being planned at the same time in different stages of their training, and generic simulations where we're trying to generically train flight controllers. So there's a lot of competition for what we call these "big rig" facilities where you have the full-up flight control team in their control center and the full-up Shuttle simulator. It takes a lot of effort to put all that stuff together.

We try to make sure that we lay out a simulation plan that tackles the portions of the mission where there's the most opportunity for confusion or error because of the complexity of the day. Some of our simulations are long sims, they'll go for 36 hours or something like that, where we'll hand over from team to team. Those feel very much like a real mission. You're going through a [crew] sleep period where you're replanning the next day and then you execute part of the next day.

STS-124 was also unique, in that it was the first time that our Japanese partners, the JAXA [Japan Aerospace Exploration Agency] flight control team, was really engaged and critical to the success of the mission. They had been brought online the flight before ours on STS-123, but the activation of that Japanese Experiment Module, the pressurized module on

STS-124, was done by commanding from the ground, and a lot of it was done by the Japanese flight control team over in Tsukuba, Japan. They're tied in through the mission control center here through Annette and her team.

[That] was an example of something that they hadn't done before. They hadn't had that kind of really high-pressure, high-visibility, really critical operations yet. So it was important that we simulated those activation timelines several times. Sometimes Annette and her team would do them by themselves, without the Shuttle side. Other times, it was the full Shuttle and Station teams together. For example, during that long simulation.

ROSS-NAZZAL: I have a lot of questions to ask you.

ABBOTT: Yes. I should keep my answers shorter.

ROSS-NAZZAL: Oh, no, [that came out wrong]! This is great, because a lot of times you answer them, but then sometimes I come up with different questions. How much time does a crew spend training on the ground for how many hours they're in space? Does that make sense? Do you have a stat for that? I know that EVA is like seven hours in the pool for every hour they're outside.

ABBOTT: Yes. I might need to go and get that number for you. That would be pretty easy to get.

ROSS-NAZZAL: I thought that might be interesting to put in the chapter, because I think that would be one of those factors that people go, "Wow, that's a lot of work for a 15-day mission."

ABBOTT: Actually, that's definitely a number that I can get for you, because now that you mention it, I'd like to know that myself. [Integrated simulations are a relatively] small part of the whole picture. There [are] about 4 launch/ascent sims and about 4 entry[/landing] sims that every crew does. They'll [also] do what [we] call a deorbit prep, which is the last 6 hours before landing, putting away everything in the cabin and getting ready to come home and then landing. There's one called a post-insertion, which is where you launch and then do the activities [scheduled] right after getting into orbit. There's a lot of cabin setup that has to be done after all the shake, rattle, and rolling of launch, and now you can get everything out and set it up.

Besides those simulations, our orbit sim template was somewhere around 100 hours, I think, of orbit sims. Approximately 120 hrs.

ROSS-NAZZAL: Can you share an example from one or two of those integrated sims for us? Some of the things that you were working on? Maybe some of the challenges or malfunctions that you encountered that stand out?

ABBOTT: That's a good question. I'm trying to think if there's a specific example. It's been a long time.

ROSS-NAZZAL: Sure, sure. Like I said, it's been a while, and these are very specific questions.

ABBOTT: There's not anything that really jumps out at me as a specific example from one of those. I'm trying to think of an example of a type of failure. Wow! That's a great question.

ROSS-NAZZAL: Did you simulate any failures with the boom, for instance? Did you have any problems with that freezing up?

ABBOTT: Yes, we did. I know we did simulate the boom transfer and all the robotics choreography. Actually now that I'm over in training management, this is [an example of] something that we talk with future teams as we get into the simulation plans for them. Throwing everything off the timeline and into never-never land really can be sometimes detrimental to the team, because it takes away the focus on getting ready for the mission. In other words, there's a balance. Every once in a while, we talk about how it's nice to see a nominal timeline once in a while, because it means hey, "This is what we're actually going to do", and running through it as a dry run for some of the complex timelines is pretty important.

I do recall some power issues that needed to be sorted out, if I remember correctly, on the Shuttle side, to make sure that we were going to feel confident that we could provide power to the boom once it got handed off to us. But I don't remember the specifics. But there were things like that that we had to talk about, maybe do some work with the crew to throw some circuit breakers and check some things on orbit to make sure. Sometimes reconfigure some systems on orbit to be able to ensure that we have what we need when we got the boom transferred.

ROSS-NAZZAL: At what point do you decide you're ready to fly? What's that process? When do you hit that point?

ABBOTT: Let's see. I'm trying to think of where to start.

ROSS-NAZZAL: It's probably a complicated question.

ABBOTT: It is, because there's different parts to it. There's the flight rules that we talked about. Making sure that we do a lot of work to understand what flight rules are needed, what parts of the mission and what specific parts of the timeline or pieces of hardware require flight rules to be written. Sometimes we'll talk for some time about whether or not we really need a flight rule for something, or whether maybe it's either not that well defined or it maybe doesn't really warrant that kind of attention.

Then there are procedures, and the checklist procedures the astronauts use and the flight control team uses to step through a particular operation, whether it's installing the pressurized module or the spacewalk procedures, things like that. Or even just operation of reconfiguring the Shuttle Systems, managing water, and some of the day-to-day housekeeping activities on board the Shuttle. They all have procedures with them. We know what procedures we need, and we know what flight rules we need. We know we need a timeline that works that fits all these constraints together. So you know those have to be done by a certain time before the mission. Of course, you want them done so you can simulate them, too. But sometimes you use the simulations to help evolve the products.

Then there's getting the Space Station ready for the Shuttle's arrival. We may need to have the robot arm and its transporter in a certain spot before the Shuttle arrives. We may need to have some of the other Station systems configured in a certain way. So what the Station team will do—and this is the Station team that's working prior to the mission—they'll put together—and this is something that the [STS]-124 team would work too—is what we call a "road to." It'd

be the road to 1J, or STS-124 that says, "Here's all the things that have to be done, here's when they need to be complete, here's maybe how much ahead of time you could have them done." Because sometimes maybe you don't want it done too far ahead, because you don't want it to be sitting in that configuration for a long time.

You take all those things together. We lay out this integrated simulation plan that says, "Here's the simulations we need to do." You look at all the team members across the flight control teams for Shuttle and Station. Everyone needs to be certified and signed off by a certain time that they're ready for that mission. Maybe it's someone who's never worked a mission before, so their initial certification is coming along. Maybe their proficiency is about to lapse, so they have to be recertified.

Take all these things and lay them out. Generally by the time we have our Mission Operations Directorate flight readiness review, we want to have all that stuff worked out. Then we'll have a set of standard open work, things that we know won't happen until after that meeting, which happens about a month or so before launch.

Then you may have some nonstandard open work, maybe something that came up at the last minute that we know we can work out, we'll be able to work it out over the next couple of weeks, but we don't have it ready yet. We'll want to flag that for the management team and make sure that they're aware. That gets rolled up to the Mission Operations level. Then that gets rolled up to the Space Shuttle and Space Station Program level. Ultimately, to an agency level flight readiness review that's usually held down at the Kennedy Space Center [Florida].

Again, all that rolls up and up and up so that the management teams, all the way to the administrator level, are aware that everything's ready, or the things that aren't ready we expect

not to be ready because they are not scheduled to happen yet, or here's something that came up that we've got to work out and we'll keep you posted [on the forward work and resolution].

There's no real short answer to your question. So getting back to your original question, we do have a good handle on all the parts, all the things that need to be worked out. That comes from experience over the Shuttle Program and with Station. It just becomes a challenge of managing all that and keeping tabs on all of it. As lead flight director, it's really my job, in coordination with Annette on the Station side, to make sure that there's no one on the team that's got something that they haven't told us about yet—that maybe there's an issue brewing that hasn't surfaced yet. We need to make sure that those all get out in the open. Then it's a matter of working through and making sure that things are methodically checked off and work gets done. Whether it's analysis that's needed, or maybe a discussion about a flight rule that we keep arguing about and haven't really come to an agreement on, and we need to [say], "Okay, it's time to make a decision here and move out."

ROSS-NAZZAL: You make it look so easy. Every time I go look at the FCR [Flight Control Room] everything just looks very calm. Tell us about the mission itself. Where were you for launch? Then you're lead on orbit, so when do you take over? Your recollections of that.

ABBOTT: For launch, as the lead Shuttle Director, my shift happens pretty much at the same time as the launch shift and the landing shift. So for launch I'm watching. There's a little management room over the control center there. I was there for the launch just to watch, really, and to listen to what's going on. Of course, right off the bat you could have some kind of anomaly with a system that may have nothing to do with launch day, but it could affect things a

few days down the line. It's a matter of really keeping tabs on everything that's going on throughout the mission from the very beginning.

For launch, I was watching, but listening and just thinking about looking for those things that would cause us to maybe diverge from what we had planned to do. Plus, it's just fun to watch. I used to work launches as a flight dynamics officer. I worked a whole lot of launches. I think I worked 15 ascents as a flight dynamics officer and 12 ascents as a trajectory officer, the flight dynamics officer's partner there. I had a lot of experience working launches back as a flight controller. So it's very interesting to me and it's very exciting, especially when now it's show time. All this preparation and planning and training and paperwork and things like that, and we're ready to go, so let's go do it. To see your friends on orbit when the early video comes down of them starting to get things done is just fantastic. To know "Okay, here we go, it's really happening now."

The launch team hands over to what we call the Orbit 2 team, which is [on during] the second half of the crew's day. They hand over to a planning team, which covers the sleep period. Then the Orbit 1 team comes in the next day, which would be my shift as the lead Shuttle flight director. I would work that shift for the whole rest of the mission up until the day before entry, when the entry team would replace the Orbit 1team. They'd come in the day before entry to basically get their "space legs" and get settled in. Some of them are common with the other team, with the Orbit 1 team, but some of them aren't. For example, the flight director: I [handed] over to another flight director [Richard S. Jones] for entry.

Once entry takes over from Orbit 1, they stay through landing. You asked about where I was for launch and landing. I was watching in management viewing room for launch. [Prior to] landing, I [thought], "This is my last mission as a flight director, and it would be cool to be able

to get out there [to KSC] for landing." So to make a long story short, after I'd finished my last shift, [the] next day I flew down to the Cape and managed to get out there for landing. As luck would have it, I was out on the runway after landing and got a chance to see the vehicle and the crew out there, so that was really cool.

ROSS-NAZZAL: That must have been really exciting for you. Was that the first landing you had been to?

ABBOTT: I'd been to landings before. Back when I was a flight dynamics officer. Actually, it was the first mission of [Space Shuttle] *Endeavour*, [STS-49]. I got out to Edwards Air Force Base [California] for *Endeavour*'s first landing. That time, too, I got out on the lake bed there where they landed, but I didn't get really up to the vehicle. For [STS]-124, I managed to. It was weird getting out of the Sun [by walking under Discovery's wing right after she had returned from space]. It was really bright and hot out there, and I thought [to myself], "Wow, I just stepped underneath the Orbiter to get out of the Sun." So that was a great opportunity, really. Actually, the crew knew I was trying to do that that day. I remember at one point standing there on the left side of the vehicle and talking with someone, and the crew transport vehicle was still attached, and I hear "Hey, you made it." I look up, [and] there was Mark [E.] Kelly. Steve [Steven W.] Lindsey [chief of the Astronaut Office] was up there with him. Yes, so it was pretty cool.

ROSS-NAZZAL: It must have been a great moment, especially since you had built this team.

ABBOTT: Yes, it was phenomenal. The vehicle looked great. It was in such good shape. If I hadn't seen it come out of the sky, they could have rolled it out of the Orbiter Processing Facility and just towed it onto the runway because it looked that good.

ROSS-NAZZAL: Tell us about the flight itself. What are your duties? We understand that Annette takes over at some point. Then you're handed back over the Orbiter at another point. Can you tell us those details?

ABBOTT: Yes, the docked portion of the mission, from once we get docked to Station until undocking, the bulk of the work is Station assembly and resupply. So a lot of the focus turns to Annette and her team for that portion of the mission, which is completely understandable. What we're there for is to assemble and resupply and transfer equipment. Up until that point though, as I said, it's the Shuttle flying on its own, and my responsibility is really for the Shuttle and the Shuttle crew throughout the mission. But before we're docked to Station, it's the Shuttle on its own. After launch, we have equipment to get set up and some inspections to do. Then actually the rendezvous and docking itself that happened on my watch, on my shift there, leading the team as we approach and then dock with the Station.

It's not so much a handover of the responsibility as much as the activities really are focused on the Station assembly. So really the CG, I guess, the Center of Gravity, shifts over to the Station world. But at the same time, my responsibilities remain the same to the Shuttle and the Shuttle crew and making sure that if for some reason we had a failure that said we had to leave, to undock and deorbit fairly quickly, that we're prepared to do that.

Then there's a lot of things going on on the Shuttle as well. There were some payload experiments. There's a lot of the equipment transfer and resupply things and transfer of equipment back that's going to be brought back to the ground. There's definitely a lot of things going on on the Shuttle only. But most of the major activities, of course, are related to Station assembly. So that is time for Annette to take over. I guess what that means for me is no press conferences during the docked mission for me. I would pretty much do the press conferences up until docking, and then we'd do a couple of joint ones depending on what was going on, and then usually Annette would take them from there because that's really where the bulk of the interesting activities are going on, over there.

Then after undocking, of course, the Station team is there on their own again, and we're on our own again, and so again it's more of a standalone Shuttle operation at that point.

ROSS-NAZZAL: Would you tell us some more information about the rendezvous and docking and how that all unfolded?

ABBOTT: I can tell you the way it unfolded was absolutely by the book, absolutely flawless. Again, it's a tribute to the training teams and to the flight control teams, and especially to the crew. The crew did a phenomenal job. Mark did a great job flying the vehicle in. It was as smooth as I've ever seen a rendezvous. It was really really great. Rendezvous day the crew wakes up. The Orbit 1 team comes in. It's a series of burns, [a] series of maneuvers with the Shuttle orbital maneuvering system engines [and reaction control jets]. We're in a lower orbit than the Station. The way orbital mechanics works, we're catching up with the Station by flying a little bit lower in altitude than the Station is. As you continue to do these maneuvers, these

little engine firings, it causes you to rise up a little bit, [and] it starts slowing the relative speed between the two spacecraft. You're catching up and catching up and catching up. Then you're slowing that catch-up rate as you raise the altitude, until you get at a point where you're right in front of the Station and in the same orbit, but out about 400 to 600 feet.

Then Mark, as the commander would start nudging the vehicle towards the Station. A lot of it, up until the final phase, is computed on the ground by the flight dynamics officer, and the rendezvous officer, who are working through computations to make sure you're pointing the engines in the right direction and firing them for the right length of time to be able to make those small course corrections and speed changes to get you there. Then you get to a point where the crew takes over, and it's mostly the astronauts who are doing their own targeting, and then Mark flying in the final approach himself.

As I said, the whole shift went flawlessly. It was just great to watch it all come together. The satisfaction of finally getting going, and I was asked that in a press conference once about "At what point of the mission are you satisfied or do you feel like you've accomplished it." I said, "I will be satisfied when that Orbiter is on the runway, and the crew is out there looking up at it, and we're done [with the mission]." Up until then, it's not. Every day has its own milestones. It's great to get them checked off. But until you have the crew back on the ground safe and the vehicle safe and we know that we did everything we were supposed to, that's when you're satisfied. Rendezvous day was one of those days. It was just fantastic to get there. It's just another one of those, "Okay, that was great, so let's get to work on the next day's worth of activities."

ROSS-NAZZAL: Any anecdotes from the mission or anything that stands out that you'd like to talk about?

ABBOTT: I'll tell you the one that comes to mind, and then we can decide whether or not it goes in the book or not. Maybe I'll just say this, and then you can tell me whether or not it's even appropriate to talk about. It's just funny that when we were working Space Station—I was a Station flight director and Ken, he worked as my CapCom for many many shifts—we got into this [thing about the] Warner Brothers cartoon with Sam the sheepdog and Ralph wolf. I don't know if you know the ones I'm talking about. But where they clock in. "Morning, Sam." "Morning, Ralph."

Okay, well, that became our little thing. He was Sam, I was Ralph. It was like "Morning, Sam," "Morning, Ralph" whenever we'd see each other. Well, I thought about that, and I found a bunch of sound clips—I guess I might as well talk about this, because we did it on air-to-ground—sound clips from those cartoons. Every morning, because Ken was the pilot, he's in charge of the Orbiter systems. He's usually the first one we'd hear from every day. Nick [Nicholas J.M.] Patrick was my CapCom for that. He'd call down. He'd say, "Good morning." In fact I think Ken started that when he called down. He said, "Good morning, Nick. Good morning, Ralph."

It was after that that I realized I needed to play something back. So I found these sound clips. I had a whole bunch of them that I would play off of my computer, and hold the microphone there so it would play that. "Morning, Sam." There were a couple of them that went on longer than that. It just became this continuous thing throughout the mission. I had to do it just about every day. Again, that was one of those fun kind of team things. It was an inside

joke between us, but of course everyone heard it. So everyone was asking about it. In fact, I heard Rob [Robert A.] Navias, the PAO [Public Affairs Officer], making some commentary about the "lighthearted banter" between lead flight director Matt Abbott and pilot Ken Ham. Poor Rob now is trying to explain this on NASA TV about what this is all about. But there's an example of something that came up that was just fun. It was nothing really to do with the mission, but more about that personal relationship thing.

ROSS-NAZZAL: Did you face any challenges on this mission?

ABBOTT: One of the things that struck us all about this flight, throughout the whole mission and then afterwards, was start to finish it really went pretty much flawlessly. There were very few anomalies on either the Shuttle or Station side. I know there were some activation challenges on the JEM pressurized module that Annette and her team had to work through. They actually used some of the alternate plans that had been put together for that. Really, it was remarkable. A few little things here and there, but really for the most part we pretty much stayed on the timeline. That was one of the things that we all found so satisfying. We thought, "Wow, you almost couldn't do it any better than we did." To me, that was a tribute to the work that all these folks did. The satisfaction I feel is in seeing what all these people that are doing their jobs can do when they work together. I feel like all I did was help make sure they were all pulling in the same direction, because it was really a huge tremendous team effort.

When I think back on it, all the worries we had about transferring the boom, and whether or not it was going to be working properly after being up there for several months, everything

just came together and went pretty much by the book from launch day through docking and landing. We launched on time. We landed on time. It was pretty amazing.

ROSS-NAZZAL: Great flight to go out on.

ABBOTT: Yes it was, it really was.

ROSS-NAZZAL: What was it like working with a new international partner, with having the Japanese on board?

ABBOTT: I got a lot of satisfaction out of it having been a Station flight director for probably the first 4 years or so of my flight director career. Not really having a chance to work with them before that, or even the Europeans for that matter. The Russians and the Canadians I'd worked with quite a bit. But the Europeans came along, their module, after I had gone back over to the Shuttle side. But to me, having JAXA come on in such a big way on this mission was really really satisfying. Having Aki [Akihiko] Hoshide on board and doing the work and getting into the module and getting it activated from the crew perspective. Then to have, finally, all the partners involved in the effort in the Space Station Program was really phenomenal.

They had been involved in the previous mission [to install] the logistics module. I always thought about it like a closet; [it's] small. That ultimately got relocated onto the big module on our mission. They had been involved [on STS-123], but it wasn't really in a major, critical, we're not going to get everything done without them" way [until STS-124]. You could hear the satisfaction and the pride in their voices, hearing them talk with Aki on orbit, the Japanese flight

control team and their CapCom equivalent talking with the crew. The satisfaction and pride that they had was really so great to hear. As a flight director, seeing all the partners around the world now part of this operation was just fantastic, really really cool.

ROSS-NAZZAL: Were there any lessons learned that you passed along from this flight?

ABBOTT: You mean with respect to the international partner aspect, or just in general?

ROSS-NAZZAL: Just in general. Anything that you learned.

ABBOTT: There's always a lot of little things that we find. Things went so very very well. I know we reinforced a lot of the things that we try to do about staying ahead of ourselves wherever we can. Thinking one step ahead, which is pretty much normal day-to-day business. It's the way we try to operate. The way a lot of folks say is, "Try to stay ahead of the vehicle." You try to stay one step ahead of what might be going on, thinking about possibly the next worst failure that might come up, and be thinking about that so if it happens you're prepared, and if it doesn't happen, well, that's okay, you were ready for it. Something happens that isn't quite as bad, well, you were prepared for worse than that.

If you prepare appropriately and the vehicle and the hardware behave themselves the way they're supposed to—it's like your car or your house, you never know what's going to happen sometimes—but the preparation is everything. All the work that you do planning and preparing for failures and things not going right, the more you do that, the better chance you have when it comes down to getting things done, getting through them without a hitch.

We were really fortunate that we didn't have to dive into those bags of tricks very much at all in this mission. But because of the planning and preparation, I knew that we were ready for whatever might come along.

ROSS-NAZZAL: Well, we're getting close to your time.

ABBOTT: I didn't even realize how much time had passed. Wow.

ROSS-NAZZAL: Is there anything else that you think we should know, either about the mission itself or about planning, training, and flying that we haven't talked about?

ABBOTT: I think there's a couple things. One is when I was "growing up" here as a flight controller, every mission was different. You could have things that went wrong on a mission that had absolutely nothing to do with the next mission. We were flying quite often, 4 to 6 times a year maybe, or more sometimes. Every mission had its own payload and its own objectives. If the major objective wasn't met—I don't think we had any cases like that—but if you had some things that didn't quite get done, okay, well, we'll figure out what's going on, if we ever fly that payload again we'll take that and turn it around. With the Space Station flights, everything is inextricably linked. It's completely tied together. If we don't do on mission A this activity or that activity, or we don't get this installed, or we don't get that moved from here to there, then mission B now has to completely change its plan, or may not even be able to be flown because something isn't ready for whatever that mission is bringing up.

There's this dependency every mission has on every other one that is so different than the way it was in the early days of the Shuttle Program before the Space Station missions. It's interesting to think back on those days, where now it's like something goes wrong on a mission that's flying now, the spacewalk was cut short a little bit because of some CO_2 scrubbing in one of the spacesuits that wasn't working properly, and they didn't get all the battery changeouts that they wanted to get done. Well, now that means the whole rest of their mission gets replanned. They have another week to fly. Of course the whole idea is to work really hard to not impact the next mission, but you could potentially impact the next mission or one downstream because these things didn't get done. We need to get them done sometime, so they'll be done on this flight or that flight. What do we not do on that flight now? Where does that go? All those things are hooked together. There's so much interdependency that it's almost if you don't break it down and just focus on one thing at a time, you can really get wrapped around the axle with worrying about all these downstream impacts. That's I think an interesting feature.

The other thing is we're approaching the end of the Shuttle Program, as you know, with I think 7 missions more after the one that's currently flying. One of the things that's so critical right now is making sure, as we approach those last missions, that we're absolutely without question applying the same level of rigor and determination and attention to detail on them that we are now. That last mission won't have a mission after it that is going to be dependent on it anymore. It doesn't mean that we can let up at all in the preparation and the training, that we need the same level of training that we do, the same level of mission planning and preparation and all those things. I think that's going to be challenging, because there's going to be the distraction of "there's no more after this one."

So that's something else I think as a Center/agency, but especially for the teams that are executing these things; it's going to be something we really have to keep in the front of our minds. We're really not an organization that slacks off anyway. I'm not really worried about that. But it's more of the distraction, and the looking to the future which has got a lot of unknowns and emptiness, and the distractions that [it] could cause for preparing for those, the rest of the missions on the manifest. So that's a couple things that are I think interesting to think about at this point in the program.

[Ad] talking about heading out to the Cape for landing [on my last mission as a flight director]. I really felt [a sense of] unfinished business. Here I am, I've worked [on this] for the last year. Other people, for years and years and years. Here we are, close to the end of the mission. Okay, it's going to be great to go out to the landing and watch the vehicle come down and see the crew right after they get back. It was my last shift as a flight director. The crew had made a nice call down. Mark and the whole crew chimed in on air-to-ground as a farewell from them. Then I made my little speech to the team about this is my last shift, and how much I enjoyed working with them, and how it's all of them that make it happen. It was something I'd thought about quite a bit. I was happy to have the opportunity to be able to do that. Some people, after a mission is over, will get reassigned, or they'll get a new job, and they won't have an opportunity. I had an opportunity to think about it. I saw it coming.

So it was an emotional moment for me. It was Rick [Richard E.] LaBrode I was handing over to, [and] he said to me afterwards, "I don't know how you held it together." I said, "It was easy, because I'm not done yet. I can't feel like I'm finished, really, until the crew and the vehicle are on the ground and they're safe." Because I could feel the emotions in me as I was talking, but there's still that unfinished business, got to get this crew back, we're not done yet by

any means. I told the team that, too. "I'm not going to be sitting here anymore," but I don't consider it a done deal until [we have a safe landing]. It was an interesting way of looking at it, because it's different with Shuttle and Station. As I said, Station continues to fly, and that's the way it should be with a long duration vehicle. But with a short duration vehicle like Shuttle, you got it up there and got the mission done. Now you've got to get it back safely on the ground, and until then you can't let up. I felt a little bit like I was letting up, but then [I had to admit], "Okay, you've got to let go, because you don't have "the keys" anymore anyway." So it was good stuff.

While I was on the plane to KSC, the crew on-orbit performed a standard reaction control system "hot fire" test of all the jets that will be used for control during re-entry. During the test they spotted an object floating behind the vehicle that had obviously just come loose. That observation started a whole lot of discussion and analysis on the ground to determine what the object was and whether it was going to be a problem for entry and landing. Now, I had actually inadvertently left my Blackberry at home, so when I landed in Florida, I called in to let folks know they could contact me on my personal cell phone. That's when I found out what was going on.

As you can imagine, I was feeling pretty helpless, now driving from Orlando [Florida] to KSC, knowing that there was a potentially serious problem with the vehicle and that I, the lead flight director, wasn't available to help. Realistically, there wouldn't have been much for me to do back in Houston anyway, since the entry and engineering teams all had things well in hand, but it played right into that "unfinished business" concern that I had. Mike Fossum later told me that soon after they spotted the object on-orbit, he said to his crew mates, "Well, I'll bet Matt is on his way back to Houston." Of course, it was very quickly determined that the object was a

heat shield clip from the rudder/speed brake on the Shuttle's tail, something that's used as a heat barrier during launch and of no concern for entry, but it still sure got my attention!

In terms of real "closure" after the mission was over, I had the pleasure – and challenge – of choosing a person or team to hang the mission plaque in Mission Control. This tradition started back in the Apollo days where an individual or group is singled out by the lead flight director as contributing over-and-above the call of duty and/or clearly exemplifying the spirit and foundations of mission operations. It's kind of like naming an MVP for the mission. Now, we have such great, wonderfully talented people in this organization that it's really, really hard to choose just one. So a couple of weeks after landing, after a lot of thought and consultation with Annette (who had the same challenge on the Station side), in a packed Flight Control Room with the crew, flight control team, engineering team, and other colleagues present, I was pleased to award that honor to Terry and Gail for their outstanding work as the lead mission planners. It was a really nice and very satisfying way to end the mission and that phase of my flight director career.