NASA STS RECORDATION ORAL HISTORY PROJECT
EDITED ORAL HISTORY PROJECT

JULIE KRAMER WHITE
INTERVIEWED BY JENNIFER ROSS-NAZZAL
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ROSS-NAZZAL: Today is April 26, 2011. This interview is being conducted with Julie Kramer White in Houston, Texas, as part of the STS Recordation Oral History Project. The interviewer is Jennifer Ross-Nazzal, assisted by Rebecca Wright.

Thanks again for joining us this morning. We certainly appreciate it. I thought I'd begin by asking you if you could give us a brief overview of your career at JSC.

KRAMER WHITE: Sure. I'm basically JSC Heritage Engineering. I've been matrixed to different programs over the years, but I've always been a part of the JSC's engineering institution. I started as a co-op in 1986 and have spent the last twenty-five years here at JSC. I started out in the Structures and Mechanics Division [currently Structures Engineering Division (SED) or ES], and I've worked all the different branches within that division. Eventually I was assigned in the early nineties to be a structural subsystem manager for the Orbiter and had a mentor who was the existing system manager, a man named Stan [Stanley P.] Weiss. I worked with him for several years until he retired, and then I became a subsystem manager. I was responsible for the wings and the tail and the control surfaces of the Orbiter, the elevons and the body flap, responsible for structural certification, repair modification.

I did that for several years, and then at the point in the late nineties where we transitioned out of NASA subsystem management into more of a contractor managed effort, I transitioned off Shuttle, worked X-38 and ISS [International Space Station] for a couple years, in a fire-fighting capacity, whatever they needed from a structures perspective, and then went back to Orbiter, and matrixed into vehicle engineering [EA4]. [It was] a similar job to what I had done before, only more of a systems engineering, more broad application, not just structures, other systems, but obviously always with a bent towards structural failures and things like that. That's the [kind of] problems I worked for the Orbiter team.

I worked there until [Space Shuttle] *Columbia* [STS-107 accident], and then I worked the *Columbia* investigation for several months. Then after that I went to the NESC [NASA Engineering and Safety Center] as a mechanical loads expert in the startup of the NESC. Stayed there for about three years and then came back [to Engineering] into my current position as the Chief Engineer for Orion capsule.

ROSS-NAZZAL: Quite a broad experience at JSC.

KRAMER WHITE: A lot of good opportunities. Right place at the right time.

ROSS-NAZZAL: You know a great deal about Shuttle, and I was interested in learning more about the pre-flight certifications of the Orbiter. Would you tell us a little bit about how those operated and if they evolved over time as you were working in structures?

KRAMER WHITE: Sure. A big part of my job in structures as a subsystem manager was certification of the primary structure. By the time I arrived, most of the fundamental certification was done. The structural test article had already been tested and the models all correlated. That was all done in the late seventies, early eighties, getting prepared for the first flight of Shuttle.

By the time I arrived, most of the emphasis was on maintaining the vehicle, so a lot of effort into structural inspections. Initially, if you go back and look at the program formulation, Shuttle was to fly many, many times a month, many, many times a year. Original certification was for ten years, a hundred flights, and by the time I joined the program, [some of] the vehicles were already ten years old.

So a big part of my job was working with the team to make sure we were implementing structural inspections and basically reeducating people about the nature of maintaining an aging vehicle versus a vehicle that was certified one time and then flew for its life and then was retired. We clearly weren't going to retire the Shuttles anytime soon, and so a big part of it was putting in place the measures to keep the certification sound, even though it was flying much longer than we originally thought.

We did do some [delta] certification, mostly around increased performance, so if the program wanted to fly a different trajectory, or the program wanted to land a heavier payload, or they wanted to land faster, we would do certification around that. Rockwell [International] would go and do the analysis. We would work with them; we would review it. As a team, we would figure out what modifications needed to be made to the airframe to support those new trajectories, or if they could do it totally analytically.

Some of the later assessments you may hear some of the people [in Orbiter that you interview] talk about “Performance Enhancement.” Some of the later loads sets for the Orbiter, we were able to do totally analytically without any major modifications, but there were several modifications to the primary structure throughout the evolution of the airframe.

Very early on, right after OV-102 [Orbiter Vehicle *Columbia*]—I always use Orbiter numbers; it's hard for me to use names. After OV-102 flew the first several flights [STS-1 to 5 in the 1981-83 time frame] and we realized how high the loads were on the wings, there was a set of modifications done right away, basically called the double-A modifications [done in Palmdale, California, between August of 1991 and February of 1992. *Columbia* underwent approximately 50 modifications, including the addition of carbon brakes, drag chute, improved nose wheel steering, removal of development flight instrumentation and an enhancement of its thermal protection system]. Some of your [NASA or Rockwell] people may call it the "Death Mod," because it was done so quickly over such a short period of time to return that vehicle to service. It put major doublers into the wings and straps on the wings and reinforcements to the spars of the wings so that the wings could take the loads on ascent.

There were mods that were rolled in, particularly as OV-103 and OV-104, *Discovery* and *Atlantis*, as they were being built. They were being built simultaneously, basically, one just behind the other in the flow; they rolled a lot of those modifications in line and did them as they were building the vehicles. Obviously, [OV-] 105 [*Endeavour*], because it came so much later, had those mods just built into the engineering.

By the time I made it, it was mostly maintaining certification and doing inspection to make sure the certification was still valid, making repairs to the airframe as necessary to keep the certification sound, so that was more the nature of a lot of the work we did.

ROSS-NAZZAL: Can you give an example of making some modifications to the airframes in terms of the trajectory or the payload?

KRAMER WHITE: Sure. If you're going to land something heavy, there's a lot higher loads on the wing, and so it's pretty simple, really. It's not that much different than airframe engineering for an airplane. You land it harder, and you need to worry about can the landing gear tied into the airframes take the loads, and then you just follow that load all through the airframe. Generally, where we would have to make modifications would be in the wing or the wing root, where we would have to put in doublers or straps to make sure the wings basically didn't yield or fail on a hard landing. It's pretty straightforward stuff, actually. It's actually real similar to aircraft modifications.

ROSS-NAZZAL: Not being an engineer, it's kind of interesting. I had no idea all these changes were going on. Tell us about certifying the vehicle. You had to sign off?

KRAMER WHITE: Absolutely. That was part of a subsystem manager's responsibilities, was to sign certification of flight readiness for every flight. We did that for the project manager. That was part of our matrix responsibilities. That would generally entail being cognizant of what the mission was; and therefore what demands were going to be placed from me, in particular, on the airframe and on the control surfaces, which trajectory we were going to fly, what landing we were going to fly, make sure it was all within the certification of the airframe.

We would have to review any kind of MR [material review] activity. If there was a problem at [NASA] Kennedy [Space Center, Florida (KSC)] or a problem at Palmdale during its major flow, we would have to review the paperwork and make sure we felt like the certification was still sound, based on whatever the problem was and whatever the repair was.

Obviously, we were involved in all that real time. When it came to the certification, that's where you rolled it all up and you sat it down in front of you and you looked at it all together and made sure holistically it all held together and it made sense. You hadn't made a series of smaller repairs that, in the end, compromised the overall system. So it involved all that.

We did inspections during that interval. If it happened to be at a depot period, OMDP [Orbiter Maintenance Down Period] or OMM [Orbiter Major Modification], we'd go back and review all that and make sure we understood what mods were made and that it all hung together to keep the certifications sound. And, yes, then we signed the certification of flight readiness and participated in the Flight Readiness Review [FRR] process if necessary.

Generally, your structures guys didn't show up at the FRR or in the MER [Mission Evaluation Room]. Obviously, a lot of people have stories about being in Mission Evaluation Room, but generally, if your structures guys showed up after you were at the pad that was a bad, bad thing. We didn't spend a lot of time with the program managers after the vehicle rolled to the pad. Obviously, our big push was getting it out the door. But once it rolled to the pad, we generally didn't interact with them a lot, didn't interact, certainly, during the mission, very seldom.

It was so unusual, at least in the early days in the nineties when I was there. It's more common now post-*Columbia*; you see a lot of discussion of TPS [Thermal Protection System] damage, which engages the TPS guys and the structures guys more into the MER. But when I was there, it was so uncommon. I can actually remember one time on a Friday night being called to the MER. Brewster [H.] Shaw was the program manager, and I can remember being called. It was so unusual to be called over to the MER. There's a rudder speed brake on the tail, which was one of my areas, and it's actually a left and right panel that opened to slow the vehicle when it lands on the runway. It was a split rudder, meaning it had an upper panel and a lower panel on each side, and it had a bulb seal between the two, upper and lower panel.

The crew member was looking out the back windows, and he sees that on ascent, the bulb seal has protruded and it's not bonded in place anymore. They show me these pictures, and they say, "What do we do? What do we do?"

I said, "Well, you can reenter. If I tell you you can't reenter, are you going to do anything about it?"

They said "Well, no, not really." At that point, pre-*Columbia*, really people didn't think about going EVA [Extravehicular Activity] to do repairs too much. So they said, "Well, no, no, we're not going to do anything about it. We just want you to tell us it's okay."

I said, "Okay."

So this would be pretty typical. We go off, we do some analysis. It's hard to analyze something like that exactly precisely, but we'd do the best we could, and we'd put some bounding conditions on it. We'd say "Well, you know, worst-case scenario, you're going to melt part of the rudder speed brake. It'll probably still be fine. It'll be effective enough, it shouldn't be a problem." At that point, we had the drag chute. "A drag chute should slow [the vehicle] down. Won't be a problem."

But that would be the kind of thing you'd do. We'd work with Rockwell, or later on in the program we'd work with Boeing, and review with them the analysis and what assumptions they were making and make sure we felt good, comfortable with the level of conservatism that was in the analysis. Then we would make a recommendation to the program manager to say, "Yes, we think it's really okay. Just go ahead and reenter. It'll be fine. Anything that happens, we can fix it after you get it back. It's not going to be a loss-of-vehicle thing."

So that was one of the very few times I can actually remember getting called to the MER, because you just didn't have structural problems on orbit.

ROSS-NAZZAL: What mission was that, do you recall?

KRAMER WHITE: I don't. I actually was looking for it in my files, and I couldn't find it. I know Brewster was the program manager, because I remember talking to him about it. I probably could find it for you if I looked around.

ROSS-NAZZAL: We can take a look too. I was just curious.

KRAMER WHITE: There's some mission where they had a protruding bulb seal on the rudder speed brake. I'm sure you could probably find it because it would have been in the MER discussions. But it was very unusual, as structures, to get called to the MER.

ROSS-NAZZAL: Were you called fairly soon after they had gotten up into orbit, or was this close to landing?

KRAMER WHITE: I think it was fairly close to landing. I think it was one of those things. This, like I said, was way before *Columbia*, so they weren't looking out the window for damage. It just so happened, whatever they were doing looking at the payload bay, the guy looked at the tail, or gal, looked at the tail and went, "Oh, that doesn't look good. This thing's sticking out of the tail." It was long before we did that kind of inspection normally.

ROSS-NAZZAL: So it was a pretty quick analysis, then, that you did.

KRAMER WHITE: Yes, I think probably within twenty-four hours we had gone through whatever analysis we were going to go through and had established that we felt like the risk was perfectly reasonable. It might cause damage to the vehicle, but we could fix it. It wasn't going to be that big of a deal to fix it.

ROSS-NAZZAL: Tell us how long it takes to certify a vehicle, on average.

KRAMER WHITE: Oh, gosh. That depends a lot. It depends a lot on what they're doing. Something very minor [like a mission specific analysis or material review analysis] is on the order of days. If it's just I'm changing a design and it's similar enough to heritage design or similar enough to previous applications, it might be a matter of days or weeks. If it's a major change, something like "Performance Enhancement," which was the last load cycle we went through on Orbiter, it was a year of analysis that Boeing wound up doing, or more, before we finally crossed all the t's and dotted the i's and said, "Yes, okay, you're good. Your certification is good." Those cycles were multiple-year cycles sometimes on the loads. By the time they redid all the stress analysis for the whole vehicle, because in many cases if it was a different-enough trajectory or if it stressed the whole airframe versus something that maybe puts extra stress on the landing gear, puts extra stress on the tail, those were smaller in scope and you could do different things, or repairs would be very limited in nature. It's all very local, so those could be done quickly.

Something like "Performance Enhancement," where we were basically asking to fly the vehicle differently and expose the whole airframe to different loads, those cycles would take a year or more, because there are just dozens of volumes of analysis. If you see an Orbiter stress analysis, it would take up this wall, this wall of cabinets, just because we generated paper for all that. Now, of course, it's all done on the computer and kept in the computers; you don't appreciate how voluminous it is. But when we actually originally certified the vehicles and did paper analysis and printed the books, it was a lot.

ROSS-NAZZAL: Tell us a little bit about the stress analysis. What did that involve? Was that primarily computer-based or were you also using wind tunnels?

KRAMER WHITE: Clearly the loads were established using wind tunnels back in the day—"back in the day when the crust cooled." A lot of it was done by hand-analysis, so they would take the wind tunnels and they would take their basic analysis and drive the external loads for the vehicle, and then they would load the airframe. And at that point, they were using the precursors to NASTRAN [NASA Structural Analysis software], and we certainly could get you the right people that could answer your question specifically about what the analytical tools were. Somebody like Glenn [J.] Miller in ES could tell you more historically kind of what tools they used.

We eventually migrated everything to NASTRAN. They had some historical codes that they used at Rockwell. I think in the end we eventually migrated everything to NASTRAN, because that's a more commonly used code now. But, yes, they did some basic finite element to distribute the load through the airframe, pretty crude by today's standards, but good enough, certainly, and then coupled with a lot of hand-analysis, actually. If you look at the volumes and volumes of stress analysis, a lot of it was done by hand. It would be using finite element models to distribute the load through the airframe, to basically get it from here's your external air loads while you're flying, here's your external environment on the airframe, and help distribute that load and then flow all those loads through all the primary structure. But when you got to a bolted joint or a certain aspect of actual structural design, all that was done by hand, and you can see that in the stress reports when you look at them. Nowadays, it's all automated. It's all done in tools like MATLAB [Matrix Laboratory programming language] and [Microsoft] Excel and basic spreadsheet-type tools or basic computational tools that they just didn't have then.

By the point where I was graduating, people were using NASTRAN, so in the mid-eighties, people were using NASTRAN and people were starting to use tools like Excel spreadsheets, but things like MATLAB didn't really exist, or if they did exist, they existed in formats in labs. They weren't really commonly used outside. But nowadays, all that's automated. They just plug the equations in, and they might be analyzing a series of stringers or a series of hat sections, and it's all done in computer code now. They just change the critical parameters and the computer does it all, whereas they used to do it all by hand.

ROSS-NAZZAL: That's amazing.

KRAMER WHITE: Yes. If you look at the volumes, a lot of them are works of art. They're just a lot of hand sketches. The vast majority of it is hand-analysis with the exception of how the loads were distributed, which was done by finite element models.

ROSS-NAZZAL: When you were working with Rockwell and Boeing, were you working with them on their efforts or were you primarily just seeing the reports that they generated?

KRAMER WHITE: A lot of our work was day in and day out with Rockwell, the vast majority. I did work with a handful of NASA guys. By the time I got there, the airframe was divided into three areas, and I had the wings and the control surfaces. A guy named Trevor [R.] Kott had the midfuselage and the forward fuselage. It seems to me he and I traded the aft fuselage back and forth, depending on who drew the unlucky straw. Then we had another gal named Lynda [R.] Estes, who did the crew module and the windows, because those were kind of specialized. We divided the airframe up.

Then we three worked a lot with Rockwell. That was really who we worked with on a day-to-day basis was Rockwell and Boeing, and so we had our analytical guys we worked with and our leads, our counterparts at Rockwell or Boeing, and we would work with them to resolve problems and figure out what we were going to tell the NASA project manager. "Oh, we can't tell him that. We need to work on that one some more." So we would spend a lot of our time either on the phone with Rockwell or at Rockwell. I spent probably half my first five years, I bet, on the road at either Palmdale or at the Rockwell facility in Downey [California].

ROSS-NAZZAL: I was curious about that. You must have spent a lot of time on the road.

When you came, *Endeavour* was a fairly new vehicle. Did you take part in certification of that vehicle?

KRAMER WHITE: I did not. When I showed up full-time in '90, of course, I went through basic intern-type training. The point at which *Endeavour* was being delivered, I wasn't in a subsystem manager role. Matter of fact, I can remember the first time I traveled with this mentor of mine, Stan, he took me to Kennedy, and *Endeavour* had just been delivered to Kennedy, and I had never been to KSC before. I showed up and we go into the OPF [Orbiter Processing Facility], and I'm so excited. I'm probably twenty-three or something, I don't know, twenty-four. I walk in and I'm like, "Where is it? Where is it? Where is it?"

And he says, "Look up," because we were underneath the belly of it, and it's probably as tall as your ceiling. So I was literally standing in the OPF underneath it and didn't realize I was standing under it. He says, "Look up."

And I look up and OV-105 has never been flown, so it's black shiny reflective almost on the bottom with all the new black RCG [Reaction Cured Glass] tile on it. I still remember. That's been over twenty years ago, but such a huge impression to see a brand-new Orbiter and just look up, and you're like, "Oh, my god, there it is," right there above you. He thought that was pretty funny. So, yes, quite an impression. But it had been delivered, and so I worked with him, obviously, cleaning up, getting ready to fly it. I'm sure there probably was some stuff I did with regard to cert [certification] for that, but I just don't recall the specifics. I was probably just so overwhelmed that I was working on a Shuttle, I can't even remember anything I was doing.

ROSS-NAZZAL: I saw that on your résumé and thought, "I wonder if she actually did any work on *Endeavour*," because I thought that would have been really cool, so it's neat that that memory has stuck with you for so long.

KRAMER WHITE: Right. Right.

ROSS-NAZZAL: Tell us about how you were able to juggle all these different orders. You've got a fleet of four Orbiters, and you're this subsystem manager. You're certifying them, but you're also getting them ready to undergo major modifications out at Palmdale, and you've got missions flying. You've got about seven missions flying every year that you're in the position. How do you maintain flight readiness, getting them ready? A big challenge.

KRAMER WHITE: We have a lot of help. The project guys are there, and we had vehicle managers on the project side that helped make sure that they kept cognizant of what work was being done out at OMDP or what work was being done in any flow, and they helped with the communication. We [the project vehicle managers] know this is going on at the Cape [Canaveral, Florida]. "We know you [the SSM (Subsystem Manager)] would want to be aware." So they would help keep that communication flowing. They would help keep decisions queued up and moving forward. "We've got to get back to the project manager with this. We've got to make a decision on this." They would work with their Rockwell and KSC counterparts on making sure we didn't drop the ball, we didn't forget we had something in the queue that we were trying to deal with. So they would help us keep things queued up and moving forward in a timely fashion.

Then obviously we had KSC engineering counterparts, NASA KSC, and over the years RSOC [Rockwell Space Operations Company] or Lockheed or USA [United Space Alliance]. We had those engineering counterparts at Kennedy, and we had Rockwell or Boeing counterparts on the West Coast. So depending on where the vehicle was and what was being done, you had people that were really watching and doing on a day-to-day basis, and as a subsystems manager, your job was keeping an eye on a lot of that. These various people helped you by keeping track of the odds and ends and keeping it queued up when you needed to make a decision, so that wasn't so bad.

Actually, over the years, you eventually learn each of the vehicles was like a child. It had its own things. It had its own idiosyncrasies. It had its own design. One of the things you asked about was, "Are they different?" Well, yes, they're all different. Their biggest differences were between [OV-]102 and then [OV-]103 and subs [subsequent, as in subsequent build]. We literally talked about it that way. That's the way the engineering was released. You had the structural test article build, [OV-0]99 [*Challenger*], that eventually became an Orbiter, *Flight* Orbiter, and then you had ALT [Approach and Landing Test], which was done with *Enterprise* [OV-101], which was its own thing. Then you had 102, which was kind of its own thing, and I'll give you some more specifics, and then you had 103 and subs. So [OV-10]3, [OV-10]4, [OV-10]5, the engineering being very similar but quite a bit of difference between 102 and 103 and subs, 102 most visibly. People would have recognized it had a SILTS [Shuttle Infrared Leeside Temperature Sensor] pod. We never took the SILTS pod off. It had the bulb on the top of the tail. If you look at it, it's got this bulbous kind of thing on the top of the tail. Then there was the debate do we take it off and put a normal tail on?

It was one of the early DTO [Detailed Test Objective] flight experiments that was done. So the pod stayed there. We eventually removed the equipment, but the pod stayed there because it was too expensive to remove it, and the certification was done with the pod there, so why bother removing it? Why pay the money to remove it? So we just always worked around that uniqueness, and that's probably the most visible attribute that people would notice. But there were just a lot of differences.

[OV-]102 is fundamentally a vehicle that's built up from structural pieces. Frames are bolted to panels. You look at the aft fuselage, and there's big structurally integral machine panels with these big frames that are bolted together to build up the aft fuselage. A lot more of 103 and subs is integrally machined. So you built 102 and you say, "Well, that went well," or, "That didn't go well." You redlined the engineering and you said, "Next time I build it, I'm going to do this, and it's going to make it easier to build it and it's going to be lighter weight." So there were weight-savings modifications that occurred between the two, and manufacturing-enhancing changes between 102 and then 3, 4, and 5 to make more integrally machined structure, to try to make it lighter weight, and make it easier to build. So those kinds of changes occurred.

[OV-]102 has what you'd call honeycombed forward spar, and the other vehicles have corrugated forward spars. Probably wouldn't think about it too much except it came into play when you talked about *Columbia* and the disintegration on the wing on *Columbia*, and it came into play just on a day-to-day maintenance perspective because it was quite different to maintain 102 with its honeycombed leading edge compared to these heavier corrugated wing leading edges that were on the later vehicles. So it was just a reality of maintenance of the different vehicles.

[OV-]103 and subs, the later vehicles, had composite spars in the wings, and that was always interesting when you moved from vehicles that had composite spars to vehicles that didn't have composite spars. The technicians were like, "Well, how come my drill bits keep getting dull on this black aluminum?"

And you're like, "No, it's not black aluminum. It's composite." And that sounds awful, but thirty years ago, it just wasn't that common. It's certainly not state of the art today, but at the time was state of the art in teaching the technicians, "No, you can't do it that way. You've got to do it—[this way].” You’ve got engineers out there working with the technicians going, “No, no, no, don’t do it that way.” Of course, the technicians taught us a lot too. A lot of time on the floor at Palmdale working with the technicians just on how to maintain it, because nobody ever built it to maintain it. The access was not in the vehicle. It wasn’t really intended to be flown for thirty or forty years, have people climbing around it doing inspections, or have them climbing around it doing modifications. It just wasn’t built to do those things.

A lot of the work we did was trying to figure out how to work our way around the limitations inherent in the engineering, that if we had thought thirty years ago, “We’re still going to be flying it thirty years from now and trying to inspect it,” we would have done a lot more. There were things done initially to try to make sure that you could inspect and you had some inspection doors, but it really wasn’t designed to be maintained for thirty years. So from an inspection perspective, it was always a challenge to do that.

There are definitely physical differences between the vehicles, and then even where the engineering is the same on 3, 4, and 5, they all had their own idiosyncrasies based on how they were built. So you knew when you built 105, we had a harder time getting the wings on, so this doesn’t quite look like that, and it’s been adjusted. If you pulled off tile, you’d find this had been done to make it match up. So you just knew from over the years of working with the technicians who had built the vehicles and working with Rockwell, who had built all the vehicles, a lot of continuity was maintained as we transitioned from our subsystem managers who came from Apollo into early Shuttle.

Most of the subsystem managers transitioned, so in the early nineties when I came on board, NASA was making a transition, and so we staggered those transitions. Rockwell maintained us through our transition and then Rockwell transitioned, and we helped maintain

Rockwell through their transition. We always staggered those transitions so you didn't wind up changing a system manager on the NASA side at the same time you changed a system manager on the Rockwell side. There was always somebody there who could remember, "Oh, here's why that one's unique," or, "Here's what's going on with that one." It was a good symbiotic relationship with Rockwell and then Boeing in terms of maintaining that continuity of knowledge on the vehicles, because they all were like children and had their own thing.

You'd be surprised—well, if you have kids. I have one, but if you had four, you remember that kind of stuff. You just knew that guy's different because it's put together this way, and that guy's different because it had this problem. Back on flight, blah, blah, blah, we did this, or back on such-and-such a flow, we backed 102 into the work stands, and so it's got a splice in the elevon, a splice that came from *Enterprise*.

So now we're talking about moving *Enterprise*, and I get calls, "Can we move *Enterprise*?"

"Yes, sure, you can. Just don't forget you've got the splice in the trailing edge." So even now I periodically get calls from the guys that are working transition of moving *Enterprise*. "Can we move it? Can we ferry it?"

"Yes, probably. Do these things. Check with this guy. Don't forget this." That's just how it works. Each one's kind of different.

ROSS-NAZZAL: Interesting. So you learned a lot from the technicians and the managers. Did you also have any sort of book that you would all keep on the Orbiters themselves, or anything that you had about the specific structures you were handling, the tail?

KRAMER WHITE: There were some basic contract deliverables that came with the Orbiters. Some particularly handy ones in terms of, obviously, the stress analysis was a deliverable and is a record of a lot of the idiosyncrasies of the primary structure, including the control surfaces. There were things called build-flow diagrams, which essentially are books that show how the Orbiter was built. It's like your Ikea furniture. "Take this piece and put it with piece and it makes this piece. And you take this piece and you put it with this piece, and now you have this sub assembly." And it literally goes from piece parts to full Orbiter assembly, and it will show you by drawing number what pieces you're putting together. It's a fabulous document, by the way. I think I have some if you would like them.

ROSS-NAZZAL: Yes, it sounds fascinating.

KRAMER WHITE: If you'd like them for historical purposes, I think I might have one or two of them. But it's a fabulous document, like if you're trying to understand how the vehicle's put together and what engineering you need to reference. We obviously had engineering logs, drawing trees. One of the other unique things about the Orbiter is it was essentially farmed out to different subcontracts. The wings were built by Grumman [Aerospace Corporation], tail built by Fairchild [Industries], forward fuselage, crew module built by Rockwell, payload bay doors built by Rockwell-Tulsa [Division], GD [General Dynamics Corporation, Convair Aerospace Division] for the midfuselage, aft fuselage was built Rockwell also. So everybody had their own drawings, and we all sort of specialized. I knew how to read Grumman drawings because I did the wings, and my buddy Trevor knew how to read GD drawings because he did the midfuselage, and we all knew how to read Rockwell drawings. And they were all different.

They all used different designations. They all used different coordinate systems. So you really had to learn to translate between how Grumman did their engineering designations and engineer drawings and how Rockwell did. So we were all translators of our own whatever subcontractor we happened to be responsible for covering. It was interesting in that regard too.

I had Grumman drawing trees and things that would help me navigate the drawing system, because it wasn't the same as the Rockwell system. We had maintenance documents. Maintenance documents were never delivered with the vehicle, because it was never intended to be maintained over that long a period of time. So a big part of what I did in the years I worked with them was help develop maintenance documents, not only as archival records but for working documents for Kennedy and Palmdale to be doing inspection. A big part of it was just what inspections are you supposed to be doing, what are the work instructions, how do you get the inspections and the work instructions tailored to each unique Orbiter, because each one's different. So you'd tell them to do an inspection and they'd go do it on 102, and they'd go, "Oh, yes, that worked great." Then they'd go to do it on 103, and they'd go, "I can't do an inspection because this bracket's in the way," or "That door's not here," or whatever.

So you'd be out at Palmdale, and you'd be rewriting the inspection criteria or you'd be out there with the technician while he's doing the inspection, and he'd say, "Is that what you want to see?"

"Well, no, that's not really quite what I want. Let's try this. Let's try that. Let's take this door off. Let's do this. Let's get a boroscope. Let's go do an ultrasonic." So you'd do whatever you had to do to figure out how to get the inspection, and we became sort of the only people that knew the intent.

So we had OMRSD [Operations Maintenance Requirements Specifications Document], which is the inspection document, which includes the structural inspections. They're called V30s. Each subsystem had its own designator, V09 for TPS, or V whatever for ECLSS [Environmental Control and Life Support System], so V30, 31 for primary structure, secondary structure. The V30s defined all the inspections they had to do and when they did it. In the early eighties we figured out, "Maybe we're not going to fly them as often as we thought we were. Maybe we're not going to want to retire them when they're ten years old." So they already had started to realize, "This maybe isn't going to work the way we thought. We better put some sustaining engineering structural inspection-type stuff into place."

We already had the subsystem stuff down pretty good. I had to make sure all my ECLSS subsystems were working between flights, check those out, normal checkout between flights. Are the batteries going to work? Is the toilet going to work? Is the power, all that? They had all that, but nobody really thought about the primary structure, built for ten years, hundred flights, don't have to do anything to it. Well, by the early eighties, mid eighties, they'd already figured out, "Mm, that's not going to work. We're going to fly them way longer than ten years." So about '83 or '84, they went off to Pan Am. Remember the big airline?

ROSS-NAZZAL: Yes.

KRAMER WHITE: Way back in the day, the airline Pan Am. So they went off and talked to them about how they developed their structural inspection for their aircraft, what the critical parameters were, how would you do this for a Shuttle. "Let's talk about how it was designed, how it was built," because those things are important in airplanes. Even though it may look like a big kind of chubby airplane, it's different. It's how it's designed. The factors of safety that are used are different than they are for aircraft. Aircraft has very stringent failsafe requirements, like it has to be able to fly with a tear in the skin. It has to be able to fly with cracks. Yes, don't look under the floorboard of your airplane. Don't look at me like that. Don't look under the floorboard in the toilet of your airplane, or you would not ever fly again.

So it has a lot more failsafe requirements than a Shuttle does, mostly because they can afford to carry the weight. Being able to fly with a big rip in your fuselage requires that you carry bigger frames to carry the load. Well, we couldn't carry all that extra weight and meet our mass margins getting off the ground, so we just are built different. They're fatigue-critical. They do these ground-air-ground cycles, pressurize, unpressurize, pressurize, unpressurize, multiple times every day. So they're driven by fatigue. We don't tend to be driven that way. We tend to be driven by static load requirements.

So what drove our inspections were different. They worked with us on that, and they talked to our system managers at the time and said, "We'll tell you what we know about doing aircraft maintenance and inspection, and you tell us what you know about how your airframe is designed. We'll figure out an inspection routine." They went and they figured out an inspection scheme. It was never intended to be the forever inspection scheme. There was no reference. Shuttle was the first reusable, obviously, airplane to space. So there was no precedent.

They took what was available as an aircraft inspection program and morphed it to the design for Shuttle and laid in a set of inspections that wound up starting in the down period after [Space Shuttle] *Challenger* [STS 51-L accident] So it was in progress, *Challenger* happened, and really started implementing it in all earnest after *Challenger*. In the down period after *Challenger*, all the vehicles were inspected.

Then the idea was that it would be a living document, that as we learned, we would change it. We set a set of intervals. While we'd go do those inspections, if we found anything, we would adjust the inspection intervals. If we inspected and we inspected several times and we never found anything, then we would lengthen the intervals [for the subsequent vehicles]. Unfortunately, when you're only flying a few times a year, it takes a long time to build that history on the airframe, but that's what we did over time. We built that history. We built the work instructions to implement the inspections. We modified the work instructions as required to meet the needs of each of the vehicles, and we would modify the inspection methods. We'd either use visual inspection or we'd use ultrasonic inspection or we would use x-ray.

As inspection tools matured over that twenty-year period, obviously ultrasonics improved a lot, eddy current has improved a lot. There's all kinds of new x-ray techniques. We would go out, and we would solicit from outside NASA, at Southwest Research [Institute] or Sandia [National Laboratories] or out in the airlines or at [NASA] Langley [Research Center (LaRC), Hampton, Virginia], wherever they were doing more of this aging aircraft work. What could we use? What tools could we use?

We would bring people in, because we had some unique challenges trying to inspect vast acreage under tile. We weren't going to remove tile. We weren't going to remove all the blankets on the outside of the vehicle. Airplane doesn't have that problem. Airplane goes through its major depot. It's stripped of its paint, it's inspected, and then you repaint delivery on it and you send it back out to fly. We can't do that. We couldn't do that with Shuttle.

We had our own unique inspection challenges, so we kind of brought in a lot of these people from outside and said, "Well, what would you do, or what tool would you apply, or what technique would you apply?" We would have to certify these techniques to try to use them on

Orbiter, involving trying it and trying samples with known defects and developing what you'd call a probability detection curve. Are you going to see it? Are you really going to see it? How small could it be? How would you set the machine to do the inspection, and if you set it this way, will it find it? And if you set it that way, it doesn't. So you'd have to develop all these work instructions and show the technicians how to use the tools. We did a lot of that over the ten years that I worked in inspection.

I worked a lot with Palmdale on that kind of stuff. Palmdale was really in many regards the proving ground, where we proved a lot of those techniques. Once they were more mature, we would tend to farm them out to KSC, and they would use them between flights if we needed them. But a lot of times that was where that kind of development occurred because they had time in major mod to do that, whereas we didn't have time in the standard flow to go do that kind of development work.

That evolved over the years, and I'm sure it has evolved since I've left and probably until the day they all roll to a stop, it's all evolving. A big part of our job was to study the results of those inspections. So we'd do the inspections, and pretty soon we'd have a history of having done that inspection on all four vehicles. Then pretty soon we had a history of two or three sequences of doing that inspection on the same vehicle, and how did the results vary and was the inspection effective and did I find anything? Would what I found lead me to do more inspection in that area or different inspection?

Corrosion's a good example. The vehicle, like I said earlier, is not really fatigue-driven. We haven't had a lot of history with cracking problems in the primary structure of the Orbiter. There are a few isolated cases where either we didn't anticipate the load properly or we had a manufacturing issue where we introduced a lot of residual stress by essentially bolting it together and putting a bunch of residual stress in it that wasn't intended to be there, so we've had a few issues. I probably could count on one hand in the primary airframe number of cracking issues we've had.

Get into the subsystems and you have a lot of failure issues just with aging and things. It's a different story. But in the primary airframe, just not very many instances. But as the vehicle aged, we did have a lot of corrosion problems. Trying to be proactive and maintain that airframe over time and not let that corrosion problem get out of hand was a constant, constant challenge. And getting the programs to be thinking about the airframe as an aging airframe. You can't just blow off the inspections. You need to go do them. We need to clean it up. Showing them was a big part. Showing them and educating them as to what the ramifications of it would be if we didn't correct it and why we needed to keep doing it on the other vehicles, and what kinds of more aggressive things we need to put into place to protect the airframes over the long haul.

No reason we couldn't use the airframes, essentially, indefinitely if we took care of them, but we really needed to stay on top of the corrosion problems. Particularly, 102 probably had the worst, for various reasons, but they all had corrosion problems as they aged. The vehicles essentially are airplane airframes. They're an aluminum alloy. They sit on the beach a significant portion of their time, particularly cumulatively when you talk about over their lifetime.

We started the program with no proactive corrosion control measures. We built them. We designed them not to corrode. I can actually remember when I first started, the guys at Rockwell M&P [Materials & Processes], god bless them, telling me, "Well, we built it not to corrode, so it's not going to corrode." And the fact that it did so well is, in fact, really a testament to the great work they did, in terms of being very proactive in choosing alloys that wouldn't corrode as easily. Choosing alloys that were corrosion-resistant, choosing alloys that, when they did corrode, they corroded gracefully. You've seen your car when it starts to corrode, it starts to exfoliate and basically the layers of the metal separate, and it looks like big sheets of sloughing metal off of an old car.

You don't want your airframe to do that. There are certain alloys that are very susceptible to that, and there are certain alloys that, when they corrode, they tend to pit, which is less detrimental from an airframe-integrity perspective. You don't want alloys that are going to stress corrosion crack, which is essentially a corrosion phenomena that propagates very rapidly and can result in catastrophic failure.

NASA had done a lot of work on characterizing metals, particularly [NASA] Marshall [Space Flight Center, Huntsville, Alabama], had done a lot of work on characterizing what kinds of metals we should be using. Rockwell leveraged all that research. "Let's use good alloys that don't corrode, that don't fail catastrophically when they do corrode, so that we'll have a chance to see it. We'll use state-of-the-art corrosion protectants, primers, paints." And that was great, and it did a great job for probably the first five to ten years with the vehicles. But after that, the primers and paints start to break down just like they do in your house, and no proactive measures really in place to deal with that. Over the years that I was with the Orbiter we did a lot of repainting, resurfacing the rudder speed brakes, the wing leading edges. We stripped them, just like you would strip an airplane, stripped them, repainted them, re-primed them, tried to separate galvanic couples.

Rockwell had rules. "Here's your rules. You don't ever put this metal with this metal, because the chemistry between them is so strong that if you put them in a saltwater environment, they will cause corrosion." So they had very strict rules about how they use the metals, and that helped, but, unfortunately, when you're building an aircraft that goes to space and you have to thermally isolate the exterior of the vehicle from the interior of the vehicle, you use alloys like inconel. Inconel is very aggressive against aluminum. You use things like gold in your multi-layer insulation to protect it thermally from heat being transferred, managing the heat being transferred in and out of the crew module. Gold is extremely aggressive to aluminum and will actually go right through the primer. It will pit right through the primer.

So no matter how careful they were, there were still cases where we didn't quite get it right, and after five years, ten years, it started to show in the airframe areas. Particularly it started basically in the wing leading areas and the rudder areas that were exposed externally to the vehicle, not purged, basically directly exposed to saltwater environment or humid air. That's where it first started to show. The body flap was another area where it first started to show. Then you started to see it inside the vehicle. You'd see it inside the payload bay. You'd see it on the 582 frame, the big frame that separates the forward fuselage from the midfuselage. We had a lot of corrosion problems on that, lots of corrosion problems on the forward fuselage of particularly 102 because of the gold multi-layer insulation blankets. Luckily, the later vehicles, they used aluminum, which actually has a weight and cost savings. It worked well enough. You didn't need the gold from a performance perspective, so they switched to aluminum, which is actually great. It's good for the airframe.

We dealt with a lot of that kind of stuff, and so for me, it worked out. It worked out really well for me. I came out of my undergraduate with an aerospace degree, emphasis in structures and dynamics and went into the Structures and Mechanics Division and did all kinds of stuff, thermal and failure analysis and things of that nature, but settled in structures.

I went back in '94 and got my graduate degree. It was kind of a crossover between materials and mechanical. Basically went on NASA fellowship on the justification that we have aging Orbiters. We don't have anybody here that knows how to deal with an aging Orbiter. We need to get more cognizant of what's going on out in industry. We need to get more cognizant of what's going on out in academia. We need the connections, we need the knowledge, and we need to bring it from the outside back in. And they said, "Yes, that sounds like a great idea." So they sent me to graduate school, and I was able to bring a lot of that back with me, both academically and then contacts both in academia, and ironically, my time in academia connected me to Langley, that I brought back to JSC.

And they [LaRC would] say, "Well, we talked to JSC," and I say, "Well, no, you don't, not as far as I'm concerned you don't. I'm the person that's in charge of structural integrity of this airframe. I don't know any of you people, and I need your help." I was able to forge relationships with some of the engineers at Langley that I have to this day that when I have materials problems, I call them. And that wound up putting me in really great stead through *Columbia* and through my time at the NESC and on to Orion. Had I stayed parochial to JSC, I [would have] just had no exposure to them, none. It was through going out into academia that I actually made these contacts at Langley that in the end I plowed back into my team at JSC to get their expertise to apply to this aging aircraft thing that JSC had no clue, but these guys did every day. Langley works every day with aircraft, people doing aging aircraft stuff. We were able to really leverage that expertise out of Langley to help us. So that was pretty cool.

ROSS-NAZZAL: That's funny, going to Utah to make that connection in Virginia. How funny.

KRAMER WHITE: Yes, it was really interesting.

ROSS-NAZZAL: While you were talking, it just jarred another question I was curious about. You mentioned having to convince folks of the real need to maintain the airframe. While you were in that position, we had an Administrator whose mantra was “faster, better, cheaper.”

KRAMER WHITE: Yes, we did, as a matter of fact.

ROSS-NAZZAL: Did that have any sort of impact on what you were trying to achieve or the improvements you were trying to make to the Orbiter?

KRAMER WHITE: Let me tell you a funny story. I started in ’90 full-time. I started in ’90, maybe early ’91, and sometime in that year or possibly in the next year, it couldn’t have been too much later than that, [Daniel S.] Goldin was down, and he wanted to have a meeting, a lunch meeting, with all the new interns.

By this point, I’d already acquired a little bit of a reputation because I worked with this guy Stan, and he was pretty outspoken. He and I got along really well, and so I was pretty outspoken. So I already had gotten a reputation a little bit. It’s great. I was raised by a great group of guys in ES, these old-school Apollo guys that were like, “You can say anything you want, you just better be right, and we will back you up, but you’ve got to be right or you’ve got to use your authority responsibly.” Okay, great. So I had a little bit of this reputation, they were kind of raising me this way.

They said, "Well, we want these interns." Somehow or other, I got selected for this list of interns, and my division chief just went, "Oh, my god."

Okay. So they send me off to this luncheon, and they said, "Please be good."

"Okay, I'll be good."

I go, and I mean I literally go into the luncheon, I pick up my lunch, and I sit at the table and I'm eating my lunch. I'm being very good. I'm not saying a word. I'm just minding my own business, and I kid you not, out of this room of thirty interns, he comes up to me and he says, "Who are you?" Dan Goldin. "Who are you?"

"Oh, I'm Julie Kramer. I'm a new intern. I work in Structures, and I'm a structural subsystem manager in training for the Orbiter."

"Oh, so you're the one who tells us if we fly." At this point, he'd already developed this sensitivity. "So you're the one who tells me if we fly ten flights or a hundred."

"Yes."

"Well, what do you think?"

"Well, I think you're not going to fly a hundred if you don't get your corrosion problems under control." Oh, my god.

He [Goldin] goes down[stairs] after lunch. This [lunch] is on the ninth floor, [the Center Director's suite is located on the 9th floor of Building 1 at JSC], and he goes down to the sixth floor [the Orbiter Project Office is located on 6th floor of Building 1 at JSC]. Dan [M.] Germany is the project manager at the time. I'd already gotten in trouble once, so I pick up the phone and I call my counterparts down on the sixth floor, and I said, "Oh, my god. Tell Dan he's coming."

Well, they didn't get to him soon enough, so he shows up in Dan's office and he says, "Tell me about this corrosion problem you have on the Orbiter." Oh, it was bad. It was just ugly. Luckily, Henry [O.] Pohl was the director of Engineering at the time, and he came to my rescue and basically said, "Well, she's right. We could have talked about a more tactful way we could have had this conversation, but she's right, and we really need to deal with this problem."

Actually, once we produced the objective evidence and showed them and could talk to them about what we could do, it's not to say we got to do everything we ever wanted to do. There were a lot of controversies about do we strip off the TPS and look for corrosion, because we were seeing signs that we might be having corrosion underneath the TPS. It had to be stripped. That's just hours and hours and millions of dollars worth of work. But we were able to work with the program. They had some objectives they wanted to achieve in terms of weight savings and changing out TPS systems, and so we said, "Great. While you're doing that, we want to do inspections. We want to be careful about how we're stripping the TPS off. We want to look at the surfaces, make sure the primers are holding up okay. We want to do sampling."

We tried to work with them to be cost and schedule conscious, but yet still get those objectives, and, of course, that's always a big part of subsystem management is trying to be responsive as an engineering community to the project's cost and schedule constraints because those are very real. I can't just say, "Hey, take the Orbiter down for a couple years and strip all the TPS off of it so I can go look and see if it's corroding." Even if I really believed that's in their best interest, that's not practical. So, trying to find a compromise through there where you can get the technical data you need to protect them from something that could happen and yet not cripple them from a cost and schedule perspective is always going to be a challenge.

And we didn't always win our arguments. There were plenty of things I wanted to do that we didn't do, but in the end, we either found ways to sample or found other ways to gather data to try to work that, and it worked pretty well, I think. From that perspective, we were able to find a lot, deal with it proactively, give them some changes they could make to help mitigate damage in the future and able to refinish specific areas and do things to help maintain the airframes. I think, overall, the airframes, at least when I left, were in pretty good shape, and I'm sure that, yes, the guys would say they're still in pretty good shape.

I would say, for the most part, I always felt like the project was pretty supportive, although they expected me to be reasonable and responsible in exercising that authority to try to say, "Look, hey, we need to do something." Usually by the time we found corrosion in the airframe, there was never a question of resources. I always got the resources I needed from Rockwell or Boeing, always got the support I needed. It was never an issue. "Hey, you've got corrosion in your airframe," and they would say, "Okay, fine, go fix it. I don't care what it costs. I don't care." They might say, "Hurry." They might say, "Hurry, hurry up, because I really want to get out of OMDP. I need to get out of OMDP. I need to keep my manifest." But they recognized that for me to do that, I needed the resources, and they were always very good about providing the resources we needed to fix the airframe. They understood that was in their best interest.

ROSS-NAZZAL: Was corrosion considered a Criticality 1 of the vehicle?

KRAMER WHITE: Well, the airframe is all considered, by default, 1:1, Crit 1:1, which is a little bit of an untrue-ism. Back in the day, nobody wanted to pay for a FMEACIL [Failure Mode Effects Analysis and Critical Item List] of the airframe, which would have required that you go through and look at each component and say, "Well, if this happened to it, would it fail? If that happened to it, would it fail?" So basically, the whole airframe, primary structure, was classified as 1:1, which generated its own set of problems. Basically, any defect in the primary structure was considered a Crit 1:1 defect, even though it might just be a scratch or an elongated hole. Over time we had to learn to deal with that and classify certain types of defects as what we used to call fair wear and tear. "It's okay if you scratch it. Just go touch it up. But if the scratch is deeper than this, go call a stress analyst. Or if the corrosion is like this, here's a standard repair. Just go do this."

Those are all very standard things in the aircraft industry, but we had no clue how to do it. We had no clue how to build a standard repair manual. We had no clue how to give the Cape or Palmdale damage limits that they could operate under with delegated authority so they didn't even have to call us. Kind of like the stuff you'd have in an aircraft depot. Send my aircraft off to maintenance, and they just clean it up. They don't call Boeing, as long as it's within the limits of the standard repair manual.

We had to learn how to do all of that and document it, and it was always a trade. How close are we to the end of the Shuttle Program, such that how much money do I want to expend into these standard repair manuals? It was always balance, and so we built them over time. We said, well, if we found we were doing a repair frequently enough, we would spend the money to have Rockwell go develop, or Boeing at the time, go develop a standard repair. And the Cape gradually over time built up a standard repair manual that they could use and Palmdale would use it. They gave them some delegated authority because of this Crit 1:1 aspect of the airframe, because all the airframe was Crit 1:1.

ROSS-NAZZAL: You've talked a lot about the different inspections that were used on the Orbiter. Do you want to talk about your time at Palmdale during the OMDPs on some of the vehicles themselves, and the major mods?

KRAMER WHITE: Sure. I'm pretty proud of the fact I've supported all the OMDPs at Palmdale, every vehicle that was there for OMDP, and then eventually assisted in transition of OMDP to Kennedy when they shut Palmdale down. So, yes, I supported all the OMDPs out there, initially starting as a structures guy, obviously working with them on all the structural inspections. And like I said, I used to spend quite a bit of time out there. I'd basically go out on three-week rotations, and I'd spend three weeks out at Palmdale and then I'd spend three weeks at home. Then I'd spend three weeks out at Palmdale and three weeks at home. The other systems managers would go as well, and we would stagger it based on what critical milestones were going on when, but we always had a structures person out at Palmdale working with the contractor.

Then later on when I was resident for 105, obviously my specialization was structures, so I tended to get drawn into structures issues, but the job was broader than that. It was more of a systems engineering role, working multiple systems, so I did get more exposure to other systems and to modifications that were going into the vehicles. Obviously, you tend to gravitate to what you know, and the other part of it is people tend to come to you because they know that's your area of specialization. So we tended to divide the issues up that way.

For 105 I was there for the full year during its OMDP, and just spent a lot of time doing everything from writing paper with the technicians and with Rockwell [Engineering]. We were pretty badgeless in that regard. Nobody really cared whether the guy that wrote the paperwork was an engineer at NASA or an engineer at Rockwell. All the technician cared about was did he get his paperwork with the signatures on it so he could do his work. So we pretty frequently did that work interchangeably.

I can remember being there second shift writing paperwork to pull bolts out of the tail, with the guy from Rockwell sitting there saying, "Well, shall we tell them to do this?"

"Yes, I think we should tell them to." It's all stuff we'd never done before, so we didn't know how to write work instructions, other than basically we knew what we wanted them to do. So we would write them, and the technicians would do it, and then they'd go, "Oh, that's not working right," and then you'd get to go back and rewrite them and redline them and work with Rockwell on getting everything sorted out and cleaned up and signed.

But it was good. It was a lot of fun, spent a lot of time on the floor, and, of course, the technicians taught you a ton. The technicians and the other Rockwell engineers just taught you so much about how the airframe was put together and why, which for somebody like me, who wasn't here during the design phase, was invaluable. You can only learn so much from looking at books and being told. You really need to get out there with the guys that built it and designed it, and that's how we learned, was getting out there, and in the process of modifying and inspecting, we learned a lot about how and why it was designed the way it was designed.

ROSS-NAZZAL: Were you also working on the wings and the aft fuselage and the other areas?

KRAMER WHITE: Right.

ROSS-NAZZAL: Were those items taken off, and then the Orbiter inspected?

KRAMER WHITE: No. During OMDP they would remove the hypergol systems. They would remove the OMS [Orbital Maneuvering System] pods in the FRCS [Forward Reaction Control System] and they'd leave those at KSC because they were uniquely qualified to handle the hot systems. Obviously, Rockwell built them, but once they were contaminated, if you will, with the hypergols, we handled them only at KSC, for the most part. Obviously we had to deal with it if we landed it at [NASA] Dryden [Flight Research Center, Edwards, California], but we didn't take those into Palmdale. So they were removed and farings were put on, fake OMS pods and a fake FRCS to keep the OML [Orbiter Mold Line], to keep the mold line appropriate for flying it on the back of the 747.

We'd fly it out to Palmdale and they'd remove those elements, and they would either open the payload bay doors or remove the payload bay doors. They would open all the access doors. There's a lot of access doors in the side of the fuselage to get you into the wings. They'd open up all the cove seals, the body flap, anything that's hinged. The body flap, the elevons, the rudder speed brake, they all have special seals around those hinges so that the flaps can articulate but they don't let hot air in. It's not like an airplane where on entry, when you look out the window, you see they put the flap down and you have a huge exposed cove. You can see the hinges and the rods that drive the elevons. You can't do that, obviously, on a Shuttle reentry because it's hot.

All that stuff is closed coves with sliding seals. They had to open all that stuff up, take it all apart to expose all the actuators and rods and primary structure. The vehicle is just chock-a-block full of multilayer insulation [MLI] blankets in the payload bay. They'd remove all that. They'd remove all those blankets off the doors. When the doors open on orbit, you can see that the radiators are there. They'd remove the radiators. They'd remove all the MLI blankets, everything that covered the primary structure. As much as they could reasonably remove, they would remove.

Then the guys would come in and start doing structural inspection. They'd go into the wings. They would use boroscopes and go into the more confined spaces into the control surfaces themselves. They all have lightning holes on the front spars. They're just basically a box construction. It's got an upper surface, a lower surface, and a trailing edge, and it's got a panel that closes off the front of it. But it's got lightning holes in it, and so they'd go in. If it was big enough in the body flap, you could almost stick your head in there and look, or you'd use a boroscope, a long snake-like visual inspection thing, and you'd go in with a boroscope and you'd look. You'd go literally fastener by fastener.

If the inspection was I want to make sure that this line of fasteners, that there's no corrosion, there's no cracking, the inspector would go, literally, "I have fifty-two rivets on this line I need to inspect," and they'd count them as they went. "Okay, I inspected all fifty-two and they're all good," or, "I inspected all fifty-two and rivet number twenty-seven has a suspect finding on it." An engineer would come in, they'd review the tape. "Oh, no, that's good. That's not corrosion. That's gypsum we ingested when we landed at White Sands [New Mexico, on STS-3]." [OV-]102 was full of it, full of it, and it was a big problem because the technicians would see it, it would be adhered to, or fused to the paint from having sat in there for so long, or water. It would sit out and get rained on, and water would run down. It would take all that gypsum and run it into the lower part of the vehicle, which is where all the corrosion would be and is. So they'd see the white gypsum and they'd go, "Oh, my god, it's corrosion."

You'd have to go out and you'd have to try to clean it out or try to take a sample. You could use a boroscope and get a sample, and you went, "Nope, it's gypsum. It's gypsum. It's all right." So we would do that kind of stuff.

We would do that in the lower forward fuselages because you can't get in there. You go in through antenna holes. They'd remove antennas from the lower part of the vehicle. There's several access doors on the lower fuselage of the vehicle for antennas. We'd open the doors, they'd remove the antennas. You could get in there with boroscopes. You could get in there. Some of the antenna holes were big enough I could fit in there up to my waist. So you'd stick your head in, into that area, the volume between the actual pressurized crew module and the forward fuselage.

The crew module is basically hung inside the fuselage to separate it so it doesn't have [body bending] loading. All the body loading, the landing loads, all the bending [portion of that load] all that goes through the airframe through the forward fuselage. It's not passed on to the crew module. The crew module is hung on a series of swing links, so you think about it like a basket that's hung inside the forward fuselage. As the fuselage bends and warps on orbit due to thermal, or bends due to landing loads, it's hanging in there and it doesn't pass any of that load onto the crew module. It's sized basically for pressurization loads. But the volume in between the two, at the back part by the 582 frame, you could actually stick your head up in there. A person could fit in there, and so you would go up in there and you'd inspect from there. Or you'd get in the wing and you'd go through the door.

There were holes in each spar, mostly for manufacturing purposes, so there were big doorways in each of the spars that would be closed off. On 102 they were closed off. I think on the subsequent Orbiters they were strengthened so that they didn't have to have the doors there, if I recall correctly. [Or maybe that was 101 that had the doors] You'd go through these doors, you'd remove the door, go through the cutout, and you'd go all the way to the back of the wing. Pretty soon, you're on your knees. Well, you could stand. In the mid part of the wing when you went in, you could stand, almost. You'd be crouched over, but you could stand.

Then you'd go to the next bay back and you'd be on your knees, and you'd go to the next bay back and you'd been on your stomach, so pretty soon you're kind of inching your way all the way back to the back of the wing on your belly and hope that the oxygen detector didn't go off because it was heck to get out of that thing once you were all the way in the back, because the inside of the wing is filled with these tubes. It's what gives it structural integrity.

It's got skins on the outside, and it's got these frames that are made with tubes to keep it lightweight. They were so fragile. They were great in tension and compression, which is what they're designed for, but you'd be in there banging around doing maintenance, because it was never designed for maintenance. So you'd be in there banging around doing maintenance, and god forbid, you'd bump a tube because you could actually literally almost squeeze it like a Coke can. It's not quite as fragile as a Coke can, but you could have. If you grabbed it, you could dent it, and then it had to be replaced. Then, your boss would say, "Don't ever come home with your name on the problem report saying that you tripped on something or you broke it or you whatever." You did not want that. You did not want to be issuing the problem report that said you were the one that caused the problem by stepping on something or busting it.

It just wasn't designed right for people tromping in and out of the wing like that, but that's how we did the inspections. We just would go in and go as far as you could, because a visual inspection was always better than any kind of nondestructive evaluation or boroscope inspection. If you could see it with your own two eyes, that was the best. So we'd send the guys in as far as they could get into the airframe, and then we'd go to boroscopes, and then if we couldn't do it any other way, we'd go to ultrasonic or eddy current inspections where you were relying on nondestructive evaluation of structure that was hidden or sandwiched in, you couldn't see it.

We never took the wings off. Putting the wings on, boy, we actually talked about that and various options of relocating Orbiters and thought, "Oh god, that would be a disaster." Getting them off and then getting them back on again would be just a nightmare. So, no taking the wings off. The wings were basically through permanent installation, as was the tail, although I think push came to shove, we could have gotten the tail off. It wouldn't have been that big of a deal. But the wings were never designed really to come off, and all the GSE [Ground Servicing Equipment] now is long since gone stored for years in Bell [Aerosystems Company] warehouse and at Downey, so really not feasible to get the wings off.

But we'd take the payload bay doors off for various modifications and/or they were composite, one of the few composite pieces of primary structure on the Orbiter. I talked earlier about the TPS weight savers, where they went from heavier blankets to lighter blankets, a lot of cases like a AFRSI [advanced flexible reusable surface insulation] to FRSI [flexible flexible reusable surface insulation], because they didn't need it from a temperature perspective, and the FRSI was lighter. They'd have to strip all that stuff off like peeling paint at your house. We eventually found some non-aggressive, environmentally-friendly stripping agents that would help the guys, but literally it was pull it back, strip it with a nonmetallic putty knife, pull it back, strip it with a nonmetallic putty knife. We had technicians that were getting carpal tunnel syndrome and all kinds of problems from stripping this stuff off of the payload bay doors and wings.

You had to be careful, because if they pushed in or they tried to use a metallic scraper, the skins were so thin, they would just go right through the skin, and then we'd have to go do a structural repair. It was a constant battle with the technicians. They wanted to get it off fast and not hurt themselves in the process, and we wanted them to take it off slow enough that they weren't damaging the substructure. So it was always a challenge to do that.

ROSS-NAZZAL: You mentioned that you worked the second shift. Were they working twenty-four hours?

KRAMER WHITE: In a lot of cases they were, particularly when we were there for structural inspection. Inspections would occur. What they would typically do is they would run visual inspection and boroscope operators on first shift, and then they'd run x-ray inspections on second and third, or anything that needed an area clear, which would be when we were taking bolts out of the tail, they didn't want people working around the vehicle in case something happened. They would have a clear in the back of the vehicles so we'd do stuff like that on second and third shift, because if there's any danger to the other technicians or engineers, they wanted to keep them away, x-rays obviously being a big one. You didn't want to be irradiating all the engineers. We would just do that on second and third, and you had to be authorized to be in there and stay in certain parts of the high bay. That's the way they kept us engineers from running around getting irradiated was they did it on third shift.

ROSS-NAZZAL: How many people do you think were working on these OMDPs, do you recall?

KRAMER WHITE: Well, from a NASA perspective or everybody? I couldn't even tell you how Rockwell was staffing those kinds of things. Hundreds of people supporting OMDP at any given time when it was up there, between the inspections and the modifications and all the systems work that was being done, hundreds of people from Rockwell and the subcontractors.

Dedicated NASA people there, less than a dozen on any given OMDP. They had a resident office out there. Orbiter Project Office had MV [mail code for Orbiter Vehicle]-8, I believe, MV-8 or MV-6, I can't remember which. I think it was MV-8 that was there in the Palmdale facility. When we weren't in a major mod, it was pretty much a skeleton crew. It was an office manager and a couple guys that watched ET [External Tank] umbilical production, and some of the other manufacturing that went on in support of the Shuttle Program in that facility.

When the Orbiter rolled in, we generally would bring some of our NASA guys up from the resident office at Downey, and we would bring in subject-matter experts from JSC or KSC to support whatever the needs were of the NASA resident office at Palmdale. So that's frequently how I would get there. I'd be there just in support of that resident office.

ROSS-NAZZAL: Then you spent some time out at KSC, but you were the chief engineer, is that correct?

KRAMER WHITE: Chief engineer for OMDP as it moved from Palmdale to KSC, so that was just broader scope. Similar scope but broader. It wasn't just inspections; it was modifications and whatever the project wanted done at that mod period. Then particularly in the case of transition from Palmdale to KSC, dealing with any issues with skills and/or making sure KSC would be able to do the same work logistically that we could do at Palmdale, because the Palmdale facility was built specifically to build Orbiters. It's just a very different footprint, very different capability than what's in the OPF at KSC. We made sure we had all the capability we needed in the OPF to do all the same kind of work, as well as all the critical skills from an inspection perspective to run all those special inspections, x-rays, and the ultrasonic eddy current. You have to have certified operators of the equipment.

Kennedy had those, but they also were running around between multiple OPFs trying to support multiple Orbiters in the flow, and so you bring a vehicle there on OMDP and the demand on that service is a lot higher. So, trying to make sure we had the right support to do all that until we transitioned it over.

ROSS-NAZZAL: Those were done in the OPF at KSC?

KRAMER WHITE: Yes.

ROSS-NAZZAL: Did you ever have any concerns about the payload bay and future payloads that were going to go in, like the Hubble Space Telescope?

KRAMER WHITE: I'm sure there were people that worried about the cleanliness, but the point that we were doing structural inspections, it was a shirt-sleeve environment, so that was done by design. You'd come in and you'd strip everything out of the vehicle. Guys would come in in shirt sleeves and basically do all the inspections. Then as you backed out of areas, you would clean them. As you finished everything in the wing, the inspectors would go in and make sure it was visually clean, and then you'd seal it. It would be like, "Okay, this is done. We're not going back in the wing." And we'd put the door on. You can't take the door off without getting into a whole series of back-out inspections and photographs again. They would just basically go in, do all the structural inspections and repairs that needed to be done, and as the paperwork was done, they would close areas out and just back their way out of the vehicle.

It was funny that you asked that question, because I can remember the first time I went to Palmdale and there's owls in the building. And the payload bay doors are open, and there's a dead rat carcass in the payload bay. That's probably not very nice for the historical archives.

ROSS-NAZZAL: Well, you can edit.

KRAMER WHITE: But it's true. It's true. It's just people think that everything is this bunny-suit environment, and, sure, inside the crew module it is, because it's really hard to clean and you can get skin and hair and dirt and things inside the crew module that are really hard to get out. So the crew module was maintained as a clean-room environment and obviously the whole vehicle, they kept very strict FOD [Foreign Object Debris] and tool control. I don't want you leaving a wrench. I don't want you leaving a badge. I don't want you dropping cigarettes, which we have done in the early days of Orbiter before they did a lot of those kinds of controls. Some guy who leans over the payload bay and dumps a pack of cigarettes, and he doesn't know how many cigarettes he had in the pack because it was open. And they'd be like, "Oh, you know what? We really need to be better about FOD control." A lot of those things are evolutionary in nature. We learned about keeping control of those kinds of things.

Palmdale was a manufacturing facility. It was built in there, and it wasn't clean room. When we did mods and we did inspections, it was not a clean room. As we would back out of areas, we would eventually tent the payload bay. When they were done and they were backing out and they were reinstalling all the MLI and they were reinstalling, closing out wiring trays and things like that, then they would go to a clean room. They would specifically tent it and vent it positive pressure to keep junk out of it and clean it really good and then back out.

Most of the time when I dealt with it, it was a shirt-sleeve environment, which actually was a treat. Then you go to KSC and they tell you you have to put a bunny suit on, you're like, "Eh, I've been in the wings. I don't need a bunny suit." So it's much stricter, much stricter at KSC.

Now, when they went into the OMDP mode, they went more like Palmdale did when they were in there doing inspections, still very strict FOD control from a tool perspective, but basically would clean it as they would go, and shut areas out once they were sure they were clean and had been inspected. So, no, we weren't very clean, surprisingly.

ROSS-NAZZAL: One of the questions that I did want to ask you, you came in the early 1990s as an engineer. Were you one of the few female engineers working in the Shuttle Program, or were there a lot of other female engineers that were working with you at that time? Was it unusual for you to be on the floor and working in management?

KRAMER WHITE: I was one of the few at Palmdale. Actually, ES, too, which was the organization I went into, was pretty integrated, if you want to say that. I had several contemporary women that I worked with, so in an org [organization] of probably a couple dozen people, there were probably half a dozen of us at a similar grade. Now, there weren't really any women above us. I'm trying to think if there were *any* women above us. I don't really think there were. In division management, all my supervisors were always men, and all the way up into the project always men, probably until, I think, late in Orbiter, probably right around *Columbia*, I think, Ralph [R. Roe] had a gal deputy. Trish [Patricia] Petete, I think, was his deputy at that time, and probably was the first female customer or supervisory-type person I had. I hope I haven't forgotten anybody.

Now, Rockwell was a little better. You interviewed Frances [A.] Ferris. Certainly she was somebody I dealt with as an Orbiter project manager, customer and on the contractor side. So I think Rockwell was probably a little more integrated than we were.

I will honestly say from my perspective I never felt like there was any issue. I was treated just the same as everybody else and given every opportunity, so I always felt really lucky. As a co-op, a lot of my female schoolmates at Purdue [University, West Lafayette, Indiana], which is fairly integrated as an engineering school goes, would talk about their experiences out in industry, either in petroleum or in industrial engineering. I had a girlfriend that worked at Kodak and a girlfriend that worked at IBM. They would come back and go, "Oh, my god."

And I'd say, "Well, I got to do this."

They'd be like, "Oh, my god, I got called Honey."

And if I got called Honey, it was because the guy was sixty, and I was twenty, and it wasn't one of those things. It was he looked at me and he thought of his daughter, and that was fine. There was never an issue with, "Well, you can't do that because you're a girl. We're not going to let you." You never ever felt that. I had absolutely awesome bosses and absolutely awesome mentors who gave me just a ton of opportunity, just as much as you could handle, which was great. Even the project managers, I never felt like there was ever any issue in that regard.

I didn't have any real women mentors, certainly. All my mentors were all these all old crusty Apollo guys, and so maybe that probably warped me a little bit, but they were great. I never really felt like there was an issue. I do still feel a little uncomfortable when I'm in a room with just women, because it's odd still, even still. Orion, now, as the next-generation aerospace program, is extremely integrated. Lots of women. Lots of women in critical engineering leadership positions, and, of course, now Engineering is very integrated, women division chiefs and women office managers, women on division staff and Center staff, so you see a lot more of that now, but certainly not when I started.

ROSS-NAZZAL: I was just curious about that. I wanted to shift gears, but I wondered if you wanted to look at your notes. I think you pretty much covered all the questions that I had.

KRAMER WHITE: I tried to.

ROSS-NAZZAL: I just thought we'd talk a little bit about *Columbia* and your work with the NESC.

KRAMER WHITE: Oh, okay, yes.

ROSS-NAZZAL: But you were very thorough.

KRAMER WHITE: Yes, I think I got most of what I refreshed my memory on.

ROSS-NAZZAL: So tell us about your work following the *Columbia* accident. You were on the Hardware Forensic Analysis Team.

KRAMER WHITE: That was one of those right place at the right time, unfortunately, lest you mistake my enthusiasm. Obviously, *Columbia* was a terrible, terrible thing, but from my career perspective, you couldn't have picked a more perfect storm of an incident that occurred. I was working in vehicle engineering at the time, so I was matrixed to the project. I was right there in their direct engineering staff. My expertise was in the wing, which was what they wanted, people that had expertise in the wing. My academic background was in aging aircraft problems, fatigue, corrosion, metallurgy.

When the accident happened, I was actually TDY [temporary duty]. I flew back and went straight to Nacogdoches [Texas], because they wanted people in the field that could tell the difference between a tail and a wing, because it's not an obvious thing to somebody that [doesn't] know the airframe. It's actually hard to tell the difference. There are subtle differences between the way Grumman built and Fairchild built, and so they were looking for people that could actually look at a piece of hardware and from very just subtle characteristics could tell is that a wing, is that a tail, is that a body flap, is it a different part of the primary structure.

I went with a gentleman from KSC NASA and a gentleman from Boeing, and we literally, the three of us, rode in a car from debris-collection site to debris-collection site. That's what we did all day long. We would go on this circuit between the debris-collection sites at Nacogdoches and Hemphill [Texas] and that area, and we would say, "That's wing. That's tail. That's something different. That's right wing. That's left wing." So that's an item of interest, and it would be red-tagged and it would be triaged and sent to Barksdale [Air Force Base, Louisiana] and on to KSC. So that's what we did.

Did that for a couple weeks, until the majority of the big debris was picked up, and then I traveled to Kennedy. At that point I went, really, merely just as somebody who had expertise in the wing as a previous subsystem manager. I joined the current subsystem manager. I joined the Boeing and the NASA KSC guys that were doing that work, just as a part of that product team. I knew all the guys and I could read the drawings. So we went and I helped with that.

I was there for a few weeks, and then I came back to JSC, and I was sitting in Ralph's MMT [Mission Management Team] meeting, whatever they were called, the NASA side of that failure investigation. I was sitting in the meeting, and somebody was telling me why the wing had disintegrated. I'm sitting in the back of the room, and I said, "Well, I have a problem with that. That doesn't work for me, because I just spent two weeks at Kennedy, and that piece of debris is on the floor at Kennedy. Next?"

The next person comes up and they tell a story. I said, "Well, I have a problem with that, because I just came from Kennedy and that debris item is item number 6," blah, blah, blah, pull out my little notebook, "See, and it's right here. It's on the grid at Kennedy."

About the third time or fourth time that happened, Ralph turns to me and he says, "I think we have a communication problem between Kennedy and JSC."

They were doing the right thing, they were trying to keep the guys at Kennedy isolated. They were trying to bring the debris to Kennedy, and the NTSB [National Transportation Safety Board] had very strongly encouraged us not to poison the investigation at Kennedy. "Don't tell them what you think happened. Let them go through the debris and figure out, based on the debris, what happened," which is the right premise from aircraft investigation perspective.

But the problem was it's a big agency, and so everybody at JSC is sitting here and they're just churning, [demonstrates], particularly once the OEX [Orbiter Experiments] data recorder showed up and they had all this data right there. You could run all these scenarios and all these possibilities, and everybody's evaluating video, and we have all these great ideas about what could have happened.

I got together with Ralph and talked about it and said, "Look. You need a gateway, a one-way valve, between Kennedy and you that's telling you what's on the floor to help you moderate what you're doing, because you're wasting a lot of time. We got a lot of people that really want to do good stuff, but they have no visibility into what's going on at Kennedy. I can't have them traveling to Kennedy en masse, because they'll absolutely poison the investigation as well as getting in the way. So how do we set up a construct that will allow us to flow information from Kennedy to here to help us focus the investigation?"

They said, "That sounds like a great idea. Why don't you go to Kennedy?"

So I went to Kennedy and stayed there for about five months, basically working with the reconstruction guys, which was done under Steve [Stephen J.] Altemus at the time. He was at Kennedy. So his job was to get the airframe on the floor. My job eventually was as a communication channel. As they were putting debris out on the floor, it was a communication channel.

What it eventually evolved into was leading the Failure Analysis Team. We need to go do this failure analysis. We need to go find this part, cut it up, do this test, whatever. So somebody needed to prioritize all the failure-analysis work that was being asked for, get the hardware cut up, get it to the right lab in the agency or outside the agency that could do the work, make sure we were being responsible with the hardware, because it was one of a kind. Once you cut it up once, you couldn't do it again. You had to make sure it was really the right thing you wanted to be doing.

So, okay, I need some help. I called this friend of mine from Langley that I had met back in the day, and I knew he had a long experience with hardware failure investigation. I called him, and said, "Could you come help?" So he came to Kennedy, a guy named Bob [Robert S.] Piascik. He came to Kennedy to help me.

I tried to get some Rockwell guys, old Rockwell guys, so I ended up with a gentleman named Mike [Michael] Ehret and a gentleman named Larry [Lawrence] Korb that I knew from way back at Rockwell. Mike had since retired, and if Larry hadn't retired, he was on the verge of retiring, but I'd known him from back in the day and Mike was the M&P lead, Director of Materials and Processes, during Orbiter build for many years. So they came to Kennedy and helped me, and were certainly invaluable. They helped me negotiate that pathway between CAIB [*Columbia* Accident Investigation Board] and NASA, because CAIB wanted to do certain things. They had an agenda. The NASA team wanted to do certain things. They had an agenda. They weren't always the same agenda.

My job was to go figure that out. Negotiate that and figure out and get the data that NASA wanted and get the data that CAIB wanted, and if there was a conflict over a piece of debris make a recommendation and figure out what we were going to do with that piece of debris. So that's what I wound up doing.

I had several failure analysts that worked with me and tapped into, I think, every lab inside the agency and some outside, and did several hundred, if not thousands, of failure analyses in that five-month window to support the investigation and the eventual final reconstruction of what happened. But, again, just a perfect combination; I was one of the few people that understood the construction of the wing, as well as could speak to the M&P community because my background was in M&P as well. I knew what tools they were wanting to use. I knew what processes they were wanting to use. I knew what was going to happen to the samples when they went to the lab, and I knew all the M&P guys. I had a foot in both communities to start with and then also had a preexisting relationship with the Orbiter Project Office, so it just worked out to be perfect that I could do that for them. It was interesting, but definitely it was not how I intended to use my academic background when I got it, but that wound up being very invaluable with my experience to go do that for them.

ROSS-NAZZAL: Were you involved at all in the tests out at San Antonio [Texas] with the foam and the wing?

KRAMER WHITE: Not so much so. Not so much so. That was a different group within the Structures Division here at JSC that supported that effort. We did more just the actual cutting up and forensic work on the airframe itself, if they would find something out there. By that time there was no stopping flow of information. It was everywhere. It was in the press. But early on, people would have a theory outside, and there were a few of us that would know what those theories at JSC were, and we would come into KSC and we would help gather data and try to capture some of that data without telling everybody at Kennedy, "JSC's latest theory is this," blech, because then they would start seeing things in the debris that maybe were or weren't there.

Being able to keep that flow of information going from KSC back to JSC and be cross-comparing that with what other efforts we're finding, like the efforts that were going on at San Antonio, to say, "Yes, we're similar attributes." Or they would show us physically what they found after they shot the test, and then we could go to the debris and we could find those same attributes. "Well, that's a unique attribute. I'm looking at a whole bunch of debris, and I'm only seeing that attribute here." So you would try to correlate that.

I think we would have gotten there even without the OEX recorder, but certainly in terms of getting a very crisp understanding of how things devolved within the wing, the OEX recorder was invaluable. But certainly when you looked at the debris field, it was very obvious where the issue had started. We were just able to put those two stories together and able to provide physical evidence to corroborate what the OEX recorder was saying.

ROSS-NAZZAL: Then you moved into the NASA Engineering Safety Center. Can you tell us about that?

KRAMER WHITE: So Ralph Roe was previously an Orbiter Project Manager. When he left that role, they put him at Langley to stand up this NESC thing, and, of course, I had a preexisting relationship with Ralph. He says, "I know what your background is. I need a mechanical analysis person. I know that's your background. Will you come and do this?"

I was on maternity leave, because I had my daughter the August after *Columbia*. I said, "Well, I'm not coming back from maternity leave early, but if you'll wait, I'll come back."

He says, "Okay."

So I wound up coming back in, I think in February, a year after *Columbia*, into the NESC as their mechanical analysis lead. That was a really interesting time for me, because it was taking me, for the first time, out of the mainline project and putting me in an independent capacity. It was really the first time I'd done any kind of independent work. Everything I'd ever done up to that point had been very in-line programs, so it's a little bit different. You're a little more sensitive to cost and schedule [in an in-line role]. You get out there in the independent world, now all of a sudden people are like, "Wow, you don't need to be sensitive to cost and schedule."

I'm like, "Whoa, wait a minute, wait a minute." So that's kind of different. Not that Ralph would ever say that, but there was just definitely the thought with some folks in this group that you're in this independent capacity and you don't need to be sensitive to those kinds of things. So it was a real—I won't say clashing of culture, because that has a negative implication, but it was definitely culture shock. NESC is composed of all ten Centers. That's one of its things. When you put the research guys in with the manned spaceflight guys, it's just a totally different culture, totally different way of problem solving, totally different way of looking at risk acceptance, all a good thing. I think the research center guys really pulled at the manned spaceflight guys and said, "Come back to your basic engineering roots. Don't be so programmatic." And the manned spaceflight guys went to the research guys and tried to pull them out of their ivory towers. "That's great, but let's talk about applied engineering."

So it's really an interesting balance of how they evolved over those first couple years of trying to pull the best from both of those orgs. Engineers that were good in their core engineering skills and still true to their core engineering skills, but could be aware and understand what the constraints were from a cost and schedule perspective, so that you could drive out legitimate technical options that a program manager didn't feel like they were just backed into a corner where you had no option at all. If you gave them an option that was so politically, schedule, or cost prohibitive, what are they supposed to do with that? It was a real interesting melding of the cultures, is probably a better way to think of it. There was some clashing at first, but melding in the end, of those cultures and trying to pull the best out of the different Centers.

Great experience, allowed me to reach outside the manned spaceflight Centers. I'd had a ton of experience with Kennedy, and even in the latter years of my time in Orbiter had a lot of exposure to Marshall because of the last several instances we had on Orbiter with the kind of aging Orbiter things, flow liner, cracking of the flow liners, BSTRA ball [Strut Tie Rod Assembly] cracking. Those are all mechanisms inside the main propulsion system that I was involved in once I moved into systems engineering, Vehicle Engineering Office. They weren't necessarily strictly structural issues, but everything that fails in the end is a structural issue. So I was working with these guys on the fatigue aspects of the flow liner and the BSTRA balls, and so a lot of that expertise, that MPS [Main Propulsion System] expertise, came out of Marshall. I dealt with people like [Robert J.] Schwinghamer and dealt with all these guys that you've interviewed, Otto [K. Goetz], and all these guys from Marshall.

I had a lot of exposure to that element, but never really any exposure at all to the other Centers. Once I moved into the NESC, a lot more work with [NASA] Glenn [Research Center, Cleveland, Ohio]. I'd had limited exposure at Langley, mostly in that aging aircraft area, so I worked a lot more with Langley and a lot more with Glenn and the other Centers. Then, of course, in the capacity I'm in now as Orion chief engineer, I'd work with all the Centers. Because we have resources from most of the Centers, all except [NASA] Stennis [Space Center, Mississippi], and a big contingent of our team is at Glenn. I was able to build on relationships within the NESC. People that I knew from NESC are now within positions within the institutions at the Centers, other chief engineer functions, other institutional positions, Director of Engineering kind of positions at other Centers. Now you know these people, so it's much easier, much easier [to get work done]. Very different than where I grew up twenty years ago where it's much more parochial to JSC. I think it's a good thing.

ROSS-NAZZAL: Did you do any work on the Return-to-Flight effort at the NESC?

KRAMER WHITE: I did. When I was in the NESC, obviously, a logical segue would have been Return-to-Flight for me, although part of the NESC, too, was to try to get some broader exposure than that. Clearly a big emphasis for NESC was Return-to-Flight. Yes, I did some of the work. Basically when they were working on the debris risk, the Debris Assessment Team type work, where they were trying to establish what probability of impacts from ice and things of that nature were, and foam, I worked some of that independent assessment. I did some of the independent analysis on ET ice, which actually was umbilical ice, which was quite large, so looking at some of the historical data on that and modeling and doing some statistical analysis, trying to establish if I thought the program models for debris damage were appropriately predicting what the risk was. I worked a lot with them on that.

ROSS-NAZZAL: Did you have any contact with the Stafford-Covey [Thomas P. Stafford and Richard O. Covey Return-to-Flight Task Group]?

KRAMER WHITE: Stafford-Covey, no. No, actually, I don't think I did. I'm trying to remember what, if any, NESC more formally engaged with them on. So I don't know if any products I did ever fed anything further up. I don't remember.

ROSS-NAZZAL: Just curious.

KRAMER WHITE: I don't think so.

ROSS-NAZZAL: I think I might have picked your brain [enough], but is there anything else you would like to talk about about Shuttle?

KRAMER WHITE: No.

ROSS-NAZZAL: Do you think there's anything that we have overlooked that you're just dying to tell us?

KRAMER WHITE: Just dying to tell you? No, I don't think so. Like I said, based on the questioning, the only thing if you're interested in the evolution of some of the tools, some of the analysis and things like that, Glenn Miller, I don't know if he's on your list, but he'd be great person to talk to. He certainly is well aware of how the evolution of the analysis went, including some of the bigger analysis challenges in terms of structural thermal mechanical analysis, tiles in conjunction with the primary structure, probably one of the bigger more unique elements of how we did analysis on Shuttle. He's well aware of all that.

ROSS-NAZZAL: That'd be great. And I thank you for your time today.

KRAMER WHITE: Oh, you're very welcome.

ROSS-NAZZAL: It's really amazing.

KRAMER WHITE: Like I said, it was a little trip down memory lane, which is good.

[End of interview]