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INTERVIEWED BY JENNIFER ROSS-NAZZAL
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ROSS-NAZZAL: Today is August 9th, 2016. This interview with Julie Kramer White is being conducted at the Johnson Space Center for the Orion Oral History Project. The interviewer is Jennifer Ross-Nazzal, assisted by Sandra Johnson. Thanks again for taking this time to meet with us over the phone. We really appreciate it. I wanted to ask if you could describe your background and how you became involved with the Orion Program.

KRAMER WHITE: Sure. Let's see. Next year I'll have been at JSC for 30 years. I'm heritage JSC Engineering. By that I mean I've spent my whole career in JSC Engineering. I started out working in Space Shuttle and worked my way up doing structures work, and then into the Shuttle Vehicle Engineering Office at JSC on the engineering side.

From there, when we had the *Columbia* accident [STS-107], I went to go work at the NESC, the [NASA] Engineering and Safety Center, for about three years. While I was in the NESC, the early RFPs [Request for Proposals] went out for what would someday become Orion. It was CEV [Crew Exploration Vehicle] at the time. Some of their Phase A activity would have started around 2003, 2004, which would have been when I was at the NESC. They started entering into I guess what would have been Phase B, some of the downselect, and then meetings with at the time Boeing and Lockheed teams. I guess Boeing was partnered with Northrop, I believe. There were two teams that were competing for the downselect, and [at that point I was still] in the NESC.

Engineering decided that as the Program Office was forming up at JSC they needed to put a Chief Engineer in that Office, and I was actively lobbying for that job. I wanted that job. Engineering wanted me back in Engineering from the NESC, so I basically told them when they were ready to give me this job, Chief Engineer for Orion, I was willing to come back to Engineering.

It was an interesting negotiation, but I eventually got what I wanted. They offered me the job. Charlie [Charles J.] Camarda was the Engineering Director at the time. Steve [Stephen J.] Altemus was the Deputy. They offered me this job and I came back to Engineering into EA4 [organizational code for the Technical Integration Office], which is the organization I'm in today, the Chief Engineer's Office.

ROSS-NAZZAL: You're not part of the Program Office within Orion? You are directly a part of Engineering at JSC?

KRAMER WHITE: Correct. That's a fundamental tenet of the way NASA does their Chief Engineer function at JSC. We're independently funded. We actually come from the institutional side. I'm EA [organization code for Engineering]-badged if you will, Engineering-badged. As opposed to GA [organization code for Orion]-badged. I'm not badged to the Program. The Program Manager is my customer, not strictly my boss, which also makes for a [more] pleasant life.

ROSS-NAZZAL: Every time I see you in the Office I think that you are affiliated and part of that. I did not realize that. That's an interesting distinction.

KRAMER WHITE: One of their fundamental tenets under their technical authority is that I'm supposed to be independently funded.

ROSS-NAZZAL: Is that because of the risks associated with engineering and issues of safety?

KRAMER WHITE: They never really used to call it tech authority, that came out of *Columbia*. I think it's really just more to keep a balance. The Program Manager worries about cost and schedule. Of course our program managers worry about technical as well. When you look at the Program Manager you think about them balancing cost and schedule with risk. They want them to have an independent adviser who's really not dependent on that Program Manager for their performance award, not dependent on that Program Manager for their feedback as to how well they did. I think of it more of as an adviser and a peer as opposed to an employee. It's easier for me to say no in some ways to a Program Manager than it is for a direct report. That's why they do it, I think.

ROSS-NAZZAL: That's fascinating. This isn't a question that we've asked everyone, but I am definitely curious about it. We were talking with Mark [S.] Geyer this morning, and we've talked with Carol [L.] Webber. It seems like Mike [Michael D.] Griffin, who was the Administrator early on when CEV was being designed, was very heavily involved in its design and the architecture of Constellation. I'm wondering as an engineer what you and the other engineers thought about his involvement and his inclusion in the design process itself.

KRAMER WHITE: Right, Chief Engineer of the Universe, that's probably the [more] politically correct [version of the] way that we used to refer to Mike. Mike is a great guy, and he was super smart. Having an Administrator that was that interested in your Program was very much a double-edged sword. As Chief Engineer I loved the fact that Mike was interested and engaged and current on what our technical challenges were. Like all engineers, he had his own thoughts about how things should be designed and done. Sometimes that could be a little bit of a challenge for us. Sometimes he was right, and sometimes he wasn't right, just like all engineers. It got to be a bit of a challenge.

It's funny that you mentioned you interviewed Carol. For me personally one of the things I went round and round with Mike about was whether or not the crew module should be composite. It's metal now. It's aluminum alloy. We went round and round about whether it should be composite because of mass savings. Typically if you can create the fuselage out of composite it would be lighter. The problem with our crew module is the shape [and the environments it's exposed to], and also it has so many cutouts and penetrations in it. Typically what they'll tell you, just rule of thumb, if it's got a whole lot of penetrations in it—that's not very technical—the trade on mass isn't as favorable. You've really got to go do the math to see which is better.

When I first came onto Orion I can remember arguments with Mike—conversations with Mike, differences of opinion with Mike. You don't argue really with the Administrator. We would literally be in a room with a bunch of people, and the engineers would be telling him, "It doesn't trade favorably; it doesn't trade favorably." He was just absolutely adamant that we needed to be composite.

Carol eventually wound up leading a trade study with the NESC. The NESC did a runoff between metallic and composite. The NESC even went so far as to build up a full-scale pressure vessel out of composite and test it. They were advancing a lot of different things, advancing the way we did analysis with composites and advancing some of the materials we used and some of the test methods. They were doing some pretty advanced composite stuff in conjunction with this demonstration. They had some other objectives as well, but basically we were trying to see if it would be lighter.

In the end it didn't wind up being lighter. Then you'd be really careful about telling the Administrator, "I told you so." You just go, "Well, look, here's the data. What do you want us to do?" "[Make] it out of metal, fine." Carol worked that really hard and spent a lot of time convincing him that really composite wasn't better. It was really a mixed blessing [having that level of engagement].

I will say I actually in some ways miss the interaction we had with Mike. Mark and I would be in Washington, DC—I'm sure he told you—we'd be in DC, if not every couple weeks, at least once a month, sometimes two or three times a month to talk to him about the details of the systems engineering. Obviously he's really interested in systems engineering, so how we were doing the systems engineering trades and what the data was indicating.

In some ways I miss that because it was great to have that much interest and visibility. He is a good engineer. Getting good interaction at the engineering level with the Administrator is certainly not something you're going to see with every Administrator, so I miss that. It did drive you crazy when he came in and said he wanted you to change your architecture.

ROSS-NAZZAL: We've heard from several people just how involved he was. I just thought that was so unusual. They seem to be much more bureaucrats than they are engineers.

KRAMER WHITE: He very much was interested in the engineering details. The downside, you had to tread lightly a little bit if you disagreed with him. That could be a little challenging.

ROSS-NAZZAL: Absolutely. You mentioned that you really advocated for this position, that you wanted to be the Chief Engineer. What was it about the position or the title? What was it? Why did you want the position?

KRAMER WHITE: I wouldn't have said it was the title so much. I think just basically career pathwise inevitably that was my career path. I was going to wind up being a chief engineer eventually. It was just a matter of timing. Orion for me, the next human transportation spacecraft, that was, for me, the pinnacle of chief engineering, as opposed to say Chief Engineer for Space Station, [a program in sustaining engineering]. That wasn't what I was looking for.

I wanted to go and do development, and this was going to be a development program from scratch basically. You were going to get to follow that development process all the way from requirements and contract award and government design requirements and analysis cycles, which is the real early stuff that's done even before the contractor does a lot of their work. Then it carries typically through the early phases of the contractor work, where you're balancing government work against contractor work, and trying to find your way through the requirement and design trade space and finally settle on what that design is that you're going to go build. You get to see the whole thing start to finish, which I had never seen in Shuttle. That very much

appealed to me, being able to be assigned to a program that did that whole process for the spacecraft.

ROSS-NAZZAL: When you came in in 2006 how robust was the design and architecture at that point? Were you still looking at mold lines and things of that nature?

KRAMER WHITE: They had populated the design pretty well through the Phase A process. Both sets of contractors had provided quite a bit of data on what the vehicle would look like. By the time I showed up, we knew a lot about the design. I would say really only it was—trying to think. Let's see. The actual contract award was the fall of 2006. Maybe 2007 the honeymoon was over, and you really knew a lot about the design, say that summer of 2007. We would have been pushing through the system requirements review process and realizing that while it looked good on paper—here's a good example, because this is what we were facing at the time. It was very heavy. This design looked great on paper, it was very robust, but as they were populating the design space with more and more detail we were figuring out how heavy the vehicle was.

As they laid in more and more detail, "Oh, we forgot this," and "oh yes, the structure has fasteners," and "oh, by the way, we had to adjust the margin because of the loads." They did all this, then all of a sudden the vehicle is like 10,000 pounds overweight. You're trying to get through your system requirements review and your system design review process, and you have to show a credible design, and the vehicle is way overweight. We had a lot of detail, but not everything in that detail was telling us a good story.

ROSS-NAZZAL: One of the things that I noticed is that the CEV was designed to be reusable, which I found interesting. You're from the Shuttle world. I was just curious what drove that design for reusability. That's how the Shuttle was sold to reduce cost, but it didn't really end up reducing cost in the end. I'm just curious about that idea behind that.

KRAMER WHITE: Right. I would even say CEV, reusability is a hot and cold thing. Everybody wants it, because they think it's the panacea for life cycle cost and in a lot of cases it's not. Either it's not as reusable as you think it's going to be or the refurbishment costs wind up driving you out of the box, and it's just better to buy something new. Where Orion is settled at now—it's been through a whole spectrum of more and less reusability over the years. When I first came on board, some of the concepts were landing on land and basically coming and picking it up and sending it back to the manufacturing facility and refurbishing it and flying it, more like Shuttle I would say.

But over the years we've figured out that landing on land made us really heavy, so we wound up going back to landing on water, which has its own implications from a life cycle cost perspective. One of the things you really sacrifice when you land in water, if you can't control where the water goes, is some of the reusability aspects. Right now there are some reusability aspects of Orion that are on the wait and see level. That's a little bit the way Apollo did it.

Apollo went through their first several flights and towards the end of the Program was actually looking at, we really could be reusing more of this hardware if we put a few seals here or adjust this aspect of the design. We could keep water from intruding, and we would be able to reuse more hardware. Right now Orion is basically at the point where we know we're going to reuse all the internal avionics. Actually that's where a lot of the money is. If you look at say 30

years ago or 40 years ago when Shuttle was built, a lot of the money was in the airframe, the manual labor that went into machining and building up this aircraft body. The money on Orion now is in the cost of the avionics boxes.

If we can reuse all the avionics boxes, which we should be able to, because they're all sealed inside the pressure vessel with the crew, that means they're always climate-controlled and we keep the water out of the pressure vessel. We keep all the bad things out of the pressure vessel because of the crew anyway, these boxes are maintained in a short sleeve environment for the most part, then we should be able to reuse them with very little effort. Fortunately for us that's a good intersection of where the cost is as well.

We'll start there. I think there will be a movement over time to want to be able to reuse more. Maybe reuse the airframe, the pressure vessel itself. But right now, some of the numbers we're thinking about to do the refurbishment, it's just easier, cheaper just to build a new one. We'll find I think that sweet spot over the first say half a dozen flights to optimize cost and salvage as much of the hardware as we can, because we know it's all real expensive. So we'll continue to work that.

ROSS-NAZZAL: I just thought it was interesting, especially because people have been so critical of Shuttle now that Shuttle has closed down. I just found that fact interesting.

KRAMER WHITE: I think it's interesting that we can't quite decide. We've been thinking about it for 10 years. I really would say the proof will be when we're flying it. We start bringing them back, and we go, "Hmm, that looks pretty good. We think we could reuse that." Much like I

think some of SpaceX's concept stuff says, "I fly crew in the pristine ones, and then I turn around and fly cargo in the used ones." That's not a bad strategy.

ROSS-NAZZAL: One of the questions the Program was interested in is talking about the multi-Center approach. Of course with all of NASA's programs it seems to be very much a multi-Center approach. Shuttle had that approach, Apollo certainly did. As I understand it, you were responsible for coordinating a lot of multi-Center technical issues. If you could talk about different regional or cultural differences between those Field Centers, and how they affected the hardware or processes or leadership as you were working on Orion.

KRAMER WHITE: Sure. That's a great question. Yes, because I think it's important for the historical record, I'll tell you the truth, 10 healthy Centers is a pain in the butt. That's what Mike wanted. From the very beginning Mike Griffin was very clear that we would be a multi-Center Program. Again there's positives and negatives that come with that. Orion is living proof of that.

The benefit we get obviously is we get to bring all the expertise from all the Centers. When you bring people from the Centers, you bring an investment and an interest of their institutions and their Centers in the success of Orion. I think that's huge for maintaining enthusiasm for the Program and support for the Program, not just political support but just Agency support. The more Centers are involved, the more Centers that feel like they have skin in the game, then you have better support within the Agency, even though I think a lot of it comes from political support as well. But I feel it's true even at the Engineering and Program level. That commitment you feel at the Agency level, because it's spread around to the Centers.

But it's a pain in the butt. The engineering team is a big engineering team, and they are spread across 9 of the 10 Centers. I'm trying to think. I have chief engineers at five of the Centers to help manage that because just the geographic distance can make communication difficult. These teams are trying to solve complicated problems. They're passing data and models back and forth, which of course wouldn't be possible if we weren't where we are technologically today to be able to pass all this information back and forth across servers and across the Internet and be able to communicate. We're much more telecon-oriented. Our guys don't think anything about a phone call that's got people from six different Centers. You're trying to balance the time zone differences, and of course that's got its own challenge with Europe as well but even within the United States with the different Centers managing the time zone issue. I would say as a net technically, it's a good thing. From a management perspective, boy, it's a hassle.

You are very correct when you say each Center has its own cultural bias. I honestly believe that what got me this job, notwithstanding the fact I pestered them to death until they gave it to me, was the fact that I had been at the NESC. Not only had I been in the Chief Engineer's Office and worked in Shuttle for a decade, or by that point almost two decades, but was the fact that I spent the last three years in the NESC. As a founding member of the NESC and [leading what was, at the time, the Mechanical Analysis] Technical Discipline Team, I was forced to make contacts at all 10 Centers. This was a part of my job. That was my job, to go establish what was the community of practice for my discipline at all 10 Centers.

I had to contact each Center. Of course I had good contacts already in the manned spaceflight Centers. I spent a lot of time working with Kennedy Space Center [KSC, Florida] and spent a lot of time working with Marshall Space Flight Center [Huntsville, Alabama]. Those

were fairly easy. As part of the NESC I got to know a lot of people at Glenn [Research Center, Cleveland, Ohio] in particular, which was a huge benefit for me as Chief Engineer for Orion. I still leverage today, a decade later, people that I met in the NESC.

Several people that were with me in the NESC at that time and worked studies with me at the time, including a " Smart Buyer activity" for Orion, which was my last NESC activity before I came to Orion; we had looked at some alternate architecture concepts within the NESC. I met a lot of people from Glenn, a lot of people from Langley [Research Center, Hampton, Virginia] that were tremendously influential as we set up these multi-Center teams. You'd have to be able to call somebody within the engineering institution at Glenn and say, "This is what I need. Do you have it? What's the priority?"

Quite frankly, when you start talking to another Center about what their priorities are, that can be really touchy. You have to have someone that you can call and say, "Hey, look now. We were all in the NESC together, so don't lie to me about what your priorities are." You have this network of people that you can call on, and you trust them to tell you, just because of your shared past history, "Here are the obstacles I'm facing in trying to meet your need." You figure out how to help each other.

I honestly think if I hadn't been at the NESC they probably wouldn't have necessarily given me this job. It was a huge leg up knowing that Mike had this 10 healthy Centers mantra that he was pushing. It made a tremendous difference to be able to say I was connected already to all the Centers.

ROSS-NAZZAL: Can you give an example where that really helped out in some cases? Maybe working on the service module. I'm not really sure.

KRAMER WHITE: Working with Glenn is one of the most obvious, because such a large percentage of our staff is up there working service module. I have very good contacts up there. It can be a really complicated technical problem you can be talking about.

I'll tell you honestly, probably where it is most useful is in the mundane day-to-day staffing challenges. Our propulsion team, we have a propulsion team here at JSC which houses the System Manager and the Subsystem Manager for the crew module. Then we have a Subsystem Manager and a propulsion team at Glenn that handles the service module. We're perpetually challenged with staffing those teams.

We're hard on the teams. We have a fair amount of turnover. They work really hard; they work long hours, keeping those teams staffed and getting them extra help. Rick [Richard T.] Manella is Chief Engineer up at Glenn. I know him from my NESC days and frequently it's a matter of just being able to call and say, "Hey, look, this is what's working. This is what's not working. We need to be able to apply more resources. My Engineering Director and your Engineering Director need to be able to talk about getting the right staffing in the right place at the right time." It's not necessarily very glamorous, but it's the day-to-day conversations that keep the team staffed and keep us from burning all the engineering teams out, that cooperative work between the institutions Center to Center.

Other examples having to do with say, for example, the heat shield on the spacecraft. Very complicated analysis. Over the 10 years I've been on Program we've switched architectures from what we call a monolithic Avcoat, which is what Apollo was, to a block architecture. It's still Avcoat material, but it's applied in a block. It's different than Shuttle tiles. If you had that in your mind, that'd be close enough.

That process of switching architectures required a lot of very complicated analysis. When you look to Lockheed Martin, who was trying to lead the change to block architecture for a lot of very good reasons, they struggled with being able to do all the analytical work that was required to substantiate the change. We were able to reach out to Langley in this particular case, who we go to for a lot of our structures needs and loads needs, because it's a very deep bench at Langley and a long heritage of doing structures work there. They supplied us.

Just basically I call them and say, "Hey, I need more help." I knew several people in the management chain there. Clayton [P.] Turner was at the time further down in the engineering chain. I could call Clayton, because I knew him and had known him for years based on time at the NESC, and was able to call him and say, "Hey, Clayton, look, I need guys that can do this kind of work." They're doing these very sophisticated nonlinear analysis runs basically for Lockheed to help feed back into the Lockheed design process to help enable the switch to this architecture.

It's a very collaborative process between the Centers, trying to get the critical skills right across the Program and being able to surge resources on and off the Program. Because the last thing Mark [A.] Kirasich wants today and that Geyer wanted before him—the worst thing for them would be to say, "I'm going to build up this huge engineering team," and then they have to continue to pay for that team for all time. That makes it really expensive.

We would try to manage those resources and basically go out and borrow. Surge on to Program, when we needed people and then shed them back out to the Centers and institutions when we didn't. That can be really complicated planning from a staffing perspective. A lot of conversations between myself and Engineering at the other Centers and with the help of the

Engineering Directorate here at JSC, how we manage those resources and we bring them on and off Program to deal with whatever the Program's critical skills issues were at the time.

ROSS-NAZZAL: When we were talking with Mr. Geyer this morning, he was talking about how initially when he started looking at workforce, JSC was busy with Station and Shuttle. So it was really nice to be able to use some of the excess workforce at the other Centers. Then of course people were anticipating that Constellation was going to pick up all of these employees here at JSC, so that's interesting to hear a broader look at all of that.

KRAMER WHITE: It's got good sides to it, but it makes it a lot more labor-intensive, just the managing of the day-to-day engineering logistics and communication. There were some ground rules that Geyer and I established early on. We talked a lot about it, how he wanted to do his engineering support. One of the ground rules we came to was that all System Managers would reside at JSC. That's still basically true a decade later. Each subsystem, like structures or prop [propulsion] or ECLSS [Environmental Control and Life Support System], they have a lead engineer. That person on the government side is called the System Manager, much like same nomenclature that was used in Station. We used the nomenclature Subsystem Manager in Shuttle, the same premise. It's the lead institutional engineer for that discipline that manages that system and its system product team, which manages the interaction with the contractor, manages the interaction among the NASA community, the crew and S&MA [Safety and Mission Assurance] and Engineering. They orchestrate that interaction.

That System Manager, Geyer wanted that person at JSC, because that is the initial first point of contact for that discipline from the Program. If he needed to be able to look that person

in the eye or have that person in the room, they were here at JSC. Once you got below the System Manager, it spreads out all over the country. A lot of the Subsystem Managers, which is the next tier down, are at Glenn and Langley. I think we even have one at Ames [Research Center, Moffett Field, California]. We have some at Marshall. That has pretty much held fast for the decade that I've been there. There is in fact one exception, and that is solid rocket motors. The solid rocket motors that are on Orion, the System Manager is at Marshall, because there was no point in us trying to manage that here at JSC. We tried for a while to have it all under a Propulsion System Manager, but the scope was just too big for any person to reasonably do that job. A couple years in we split it out to Marshall. There's been no real issues with that. The desire to keep the System Manager located with the Program Manager has continued to be a ground rule for the Program.

Of course I like that too, because it keeps them collocated with me, makes my job easier too for the same reasons. Those are the kind of things you have to think about when you're trying to manage that inter-Center team. How much of that do you allow to migrate out to the Field Centers? It does complicate just day-to-day interaction.

ROSS-NAZZAL: I wanted to ask you about February 1st, 2010. Did you have any idea what was coming down the pike? Was that just a complete shock?

KRAMER WHITE: February 2010, what happened in February 2010? No. It's blocked out in my memory. I actually was totally surprised. No idea. We thought the launch vehicle was going to get cut. The rumor mill was the launch vehicle was going to get it. That really had been the

gossip. It'd be interesting to see what Geyer says. To me, I had no clue at all that we were going to get caught up in that.

ROSS-NAZZAL: Even with the Augustine Report you weren't thinking that that might be a possibility?

KRAMER WHITE: There's a lot of those things that come and go. So no, I honestly wasn't really seeing that as a big threat. I looked at that like, "Okay, here we go again." Honestly, I can even remember telling myself, "We let a $3 billion contract. Who's going to novate a $3 billion contract? Really seriously? Nobody. Nobody." I remember when I came to Orion, "This is the best deal ever." Once the contract award was made in the fall I was like, "Nobody's ever going to novate this. It may take us twice as long as we say it's going to take us, but nobody's going to novate that contract."

I was shocked. Just absolutely shocked.

ROSS-NAZZAL: What are your memories of that day, coming into JSC? What was going on in the Office at that point? Lockheed, I'm guessing, you worked with them pretty closely.

KRAMER WHITE: Yes, Lockheed I think handled it much more gracefully than we did. When I say we I don't mean everyone. Mark handled it gracefully. The rest of us not so much so. Maybe it's part and parcel to to some extent the ebb and flow and coming and going of contracts. In a contractor world, that's the name of the game and part of the business. Their immediate reaction was certainly not positive. They were like, "Okay, this is really bad," but they

immediately set the gears turning with their lobbyists, finding out what was going on, and why and what could be done, and already talking about how things could be restructured or salvaged. They were way ahead, and then certainly they were talking to Mark about a lot of that I'm sure.

But the rest of us, I don't think I would be exaggerating it to say, had waited our whole careers to do this job. We're thinking who's going to novate a contract, nobody, so we're going to build this thing. We're going to build this sucker, it may take us a little longer, but we're going to build it. We're going to do this thing that we had always wanted to do, which was cradle to grave do the development and build this spacecraft. And, at the time, go back to the Moon, a rocket scientist's dream to do that.

I personally was devastated. I don't think it would be exaggerating to say I was devastated. I think a lot of people were. I don't think the government guys handled it very well. A lot of us went drinking, quite frankly, and said, "Well, what now?" I would say for that first 24 to 48 hours I think a lot of the government folks were in a "Wow! I wasn't expecting that, what now mode." I think to some extent I do give Lockheed a ton of credit for pulling us out of that funk, for no other better term, to say, "Hey, look, there are still options. Let's talk about what those options are."

I'm sure I have a very selective recollection of that, because it was very traumatic. It seemed to me 24, 48 hours before we regrouped and started talking about what options were really available to us, and then Mark regrouped the NASA senior management team, "Okay, here's what we're going to have to start doing and keeping the team moving forward." I think a phrase uttered very frequently was, "Head down and color. Don't look up. This too shall pass. Just head down and color, folks. Don't pay any attention to what you're hearing." That's hard. It's all over the local news; it's all over the Internet. You've got people within the executive

branch openly battling with the legislative branch about your Program. This thing that you've invested at this point four, five years of your career working on, and feel like you're really close. Watching them openly discussing your future in not a positive way was tough. It was very tough.

ROSS-NAZZAL: Talk about those options that Lockheed came to the Program and presented as viabilities to keep the Program going while all of this is going on in the background that you talked about. Congress is upset because they didn't know that the President was going to do this.

KRAMER WHITE: Right. I think the most obvious options became what was EFT [Exploration Flight Test]-1. Shed some content, show progress quicker, which seemed to be everyone's gripe, look at the money that's been spent without progress. I think it's very hard, unless you were a part of the perspective from the beginning—of course whether that poisons you or not I don't know, ruins your objectivity.

Mike Griffin had a vision, right or wrong, that this vehicle was to be the once-in-a-lifetime investment, the be-all end-all perfect spacecraft first time off the line. We were going to build this vehicle and the first unit, first serial number 001, that rolled off the assembly line was going to be the configuration. It was going to have all the bells and whistles that we wanted to do exploration for the next 30 years.

There was a lot of rewinding and doing again. Mike's ideas, but not just Mike's ideas. I want the power system done this way, or I want this attribute of the design to be this thing. If we wanted it to be perfect the first time it was coming off the line, there was by necessity a lot of rewickering and redesigning. That took a lot of time, and it cost a lot of money.

When some of the criticisms were "Look at the money that's been spent and the lack of progress," we certainly didn't see it as lack of progress. We felt like we had a ton to show for the money that had been spent. I think in the end the work that occurred that maybe a lot of people don't subscribe value to, I think was tremendously valuable to us as an engineering team. But that's neither here nor there.

Most of the plans were anything that could show demonstrable progress in the shortest period of time. Progress was of course smoke and fire because this is NASA, so you had to launch something. It really didn't matter as much what you launched as that you launched something. You reverse-engineer, if I can launch this on a certain date with the engineering value associated with that, which sounds a little bit weird but in some ways was true. What were the fundamental pieces that we already had in place and knew the primary structure? The heat shield—things that would have value if you could demonstrate them now. You weren't going to roll off the assembly line with the final vehicle.

But now we're at a different place. Mike Griffin is gone, and the mantra is more about this design, build, test, fly, redesign, build, test, fly. It's this iterative design cycle. Honestly either way works, quite frankly. In some ways as an engineer I find where we are today easier, because you build a little, you test a little. You don't like the result; you start again. You don't have so much invested that you can't change it.

Lockheed looked at options and brought options and talked to NASA about well, look, clearly people aren't happy with the demonstrated progress we're making. So what could we do that everyone would agree would demonstrate that we've made progress? Okay, we pretty easily could build the pressure vessel, because the engineering is done. It's a little heavy. If this were the final design we'd go send it back through a mass reduction activity. Frankly it's light

enough, particularly if it's not fully populated with all the systems, that we could launch it on an expendable. Okay, well, now I don't even need a rocket. I can go buy a rocket off the shelf. What mission can I do with that? Would that mission be useful to me?

You start looking at it like well, okay, if you can get it out far enough that you can get it in the Van Allen belt, and you can get it out far enough that you start to see the radiative effects of a high speed reentry, got to get out of low Earth orbit, further out to get the speeds up high enough that you start seeing the radiative effects of reentry. So how far can we get the vehicle out? Okay, well, if I can get it out that far, I'm going to test the core avionics for radiation susceptibility. I'm going to test the heat shield under a higher speed reentry than I can get from low Earth orbit. I can test the parachute system. All these high risk attributes of the design, I could burn those down early, learn a lot, show this progress that people are fussing about, and everybody's happy, for a fraction of the cost of what it would take to go build the final vehicle, in a fraction of the time.

That was where EFT-1 wound up coming on the scene. From my perspective—again of course I'm not sure how objective I am—but I think a good success—and certainly from an engineering team perspective, to be able to keep the engineering team motivated and keep them moving. To be able to see the fruits of their labor if you will, do something that hasn't been done in [four decades], that's a huge motivator, and has allowed I think more longevity on the team. The team works on something for a decade. If they haven't flown anything it's hard to keep them hanging on.

EFT-1, tremendous morale booster internal to the Program as well. I would say is a big contributor for how we've managed to keep longevity, some of our key engineering folks on Program for as long as we have.

ROSS-NAZZAL: What were some of the more memorable events or moments that you can think of that led up to EFT-1? Are there any things that stick out in your memory?

KRAMER WHITE: You mean in terms of the process of building up the vehicle and getting it ready for flight?

ROSS-NAZZAL: Any of those things. Or, I don't know, maybe meeting someone from Congress talking about this. Whatever stands out in your memory from that time period.

KRAMER WHITE: All that stands out in my memory in that period of time was working a lot.

ROSS-NAZZAL: I imagine so.

KRAMER WHITE: Until we flew. We were laughing. One of the guys I work with on the heat shield and I were laughing, because the Christmas after the flight was the first Christmas that he and I hadn't been working basically through the Christmas holiday in four years. We'd get maybe a few days off around Christmas, but then inevitably we were tied up in phone calls and meetings through Christmas and through furlough. Yes, furlough. I worked. A lot of us worked during furlough. It just seemed like one thing after another. If you say what stands out, I probably would rattle off a litany of technical issues that were my favorite technical issues as we built up the vehicle.

With those, the amazing effort I think of the people. Funny whatever weirdness you get when people are working all kinds of hours. It was great. The folks were great and obviously highly motivated to get done, so a lot of team bonding.

The good things like getting to meet people, to me that all came post EFT-1. They sent me off to go meet the President [Barrack Obama], which was cool. I think regardless of your politics, you got to say meeting a sitting President is pretty cool. That was neat. Of course after the flight, everybody was awesome, everybody that lives in Clear Lake. Of course my dad, he lives in Indiana. He already thinks NASA is awesome, so he thought it was that much more awesome. That kind of stuff.

Leading up to EFT-1, it was so busy. You almost couldn't think about it. I think until we got to the very end. I can remember being there when they rolled out stacked with the Ogives and the LAS [Launch Abort System] attached getting ready to go to the pad.

You find yourself taking pictures because you almost can't even imagine that it's finally real after all those years and after all the hours and hours and hours of work, just crazy, crazy work, and feeling like you go from one problem to another. I think the one disadvantage of being Chief Engineer, I'm sure Mark experienced this as Program Manager too, people don't generally bring you the good stuff. It just seems like day after day you're faced with what turd happened today, what problem is there that's got to be dealt with. Didn't frequently take enough time to go look at the good stuff that was happening. Probably fairly seemed like a miracle in my mind that the damn thing was even ready to fly after all that.

There was a lot of people making a lot of good progress day to day that we didn't necessarily see. I would make it a point—and I'm getting back to that right now, because I've been out of it for a while—but I would make a point of getting down to the Cape [Canaveral,

Florida], if I could swing it, every month, two months at the most, just to literally fly in, maybe talk to somebody about something specific, meet the people working on the vehicle, talk to my Chief Engineer at KSC, just to go down and see the vehicle. Just so I could reground myself "Look at all this progress we're making; look at where it is in its build cycle." I'd say, "I'm going to go and hug it." I'd say, "I'm going to go fly to the Cape and hug the vehicle because I'm tired of this administrative crap you guys have me doing."

I would go do that and I'd come back and inevitably felt better for days, just having spent some time with the hardware. It did seem rather overwhelming sometimes, the day in, day out dealing with the logistics and issues of getting the vehicle ready for flight.

ROSS-NAZZAL: Was your family there when EFT-1 launched? Obviously you didn't get to spend much time with your daughter as you were working on this effort.

KRAMER WHITE: Yes, ma'am, thank you for remembering. Cece went with my husband. Cece and my husband went to the launch. It was really nice for all the families that got to go, because people were working these crazy hours and it was nice to finally be able to show them what was going on. Matter of fact, the spring break before we flew, so that would have been March of 2014, I took my daughter and husband to the Cape with me for her spring break. Of course I had work to do, but I took them with me and got her in to see the vehicle. So that at that point she could say, "Oh, okay, this is what you're spending all these hours on."

At that point it looked like a spaceship. You had the pressure vessel, and it had the wiring and the tubing, and the tanks all attached. They didn't have the backshells on yet but she got to meet the guys that were doing all the work. It was in the clean room at the time, and she

could see it through the glass. She actually knew some of the guys that were working on the vehicle, so they'd come to the glass and knock on it and wave to her. I'm like, "Oh, that's so-and-so, that's Mr. so-and-so." She'd be like, "No way." I'm like, "Yes, he's in a bunny suit, you can't hardly tell, but that's who that is."

She got to walk all around, and she got to see the guys putting the tiles on the backshell. She talked to them about putting the tiles on the backshell. I think it made it a lot more meaningful for her to be able to see why I was always running to KSC, and why I was always going in and out. It was a big help. Then she got to see the launch and see all the excitement. She was out on the causeway with everybody else. Of course I didn't get to see her during the launch. She saw a lot of people she knew, and she saw a lot of people she didn't, strangers, people that maybe didn't even have anything to do with NASA in particular that were there and were excited about the launch.

It was a great experience for her and my husband as well. They put up with a lot, so it's nice to show them what it is that you're spending all that time doing.

ROSS-NAZZAL: What were your feelings that day? You said you'd been working so hard, and it's finally here. It's happening. But what are your recollections of that day and seeing it lift off and return? Things just went pretty flawlessly as I understand it.

KRAMER WHITE: Right, the first launch attempt, the anxiousness in the room was almost palpable. Everybody was very excited and very anxious and of course hadn't slept, even though they tell you to sleep. You're like, "Right, okay, fine," because the launch attempt was first

thing, so by the time you did the count—I think our call to stations was midnight or something. They were like, "Yes, make sure you sleep before you show up." Of course nobody slept.

We were all just wired. Everybody had drunk about a pot of coffee and was very excited and spun up and ready to go. Just couldn't get the Delta IV off, just couldn't. We actually kind of thought they were jerking our chain over at ULA [United Launch Alliance]. I think they were running the count and then going, "Oh, hold, hold, hold. Watch what the NASA guys are going to do. This is going to be funny." We joked that they were just pulling our chain, because we'd get so excited, and then they'd say, "Oh, hold, hold, hold."

I don't know how many times they did it. We got through that whole process and then they scrubbed. Then you're like, "Oh. Okay," just this huge disappointment. I don't remember any of that with Shuttle. I guess it's because Shuttle had gotten to the point where it was so common. Quite frankly, typically I worked structures issues, so by the time you launched, most of that was taken care of. I don't remember that sense of anticipation and the letdown with a scrub with Shuttle. I'm sure some Shuttle people did. I'm sure STS-1, the first few of them, there was a lot of that. That was totally new to me.

To me the interesting contrast was then the second night everybody came back, and people had slept more, just because they were exhausted and couldn't stay awake any longer. How much calmer it was the second night. It's hard to describe. It almost felt like "Okay, now we're serious. Let's go launch." Just very calm. Everybody was much more laid-back. You felt like there were these points that you knew were the most dangerous in the mission, and so you could feel people hold their breath a little bit. It didn't have that same kind of energy and angst like the first night did. Of course everybody holds their breath on the launch.

As a matter of fact, ULA and Lockheed had tried to indoctrinate us a little bit on the Delta IV Heavy. A lot of us had never worked with a Delta IV Heavy. It has that lovely fire that comes up the side of the Delta IV from the propellant burnoff. They'd showed us videos. They'd shown us launches. They're like, "Why don't you come and see a launch? Because you need to see it to know what's going to happen."

Most of senior management had, by that point, seen a Delta IV Heavy launch, and I told my daughter and my husband. I said, "This is not a Shuttle." She had seen a Shuttle launch; she had seen two of the last Shuttle launches. Shuttle gets off the pad very fast. It's got those solids, and for such a big vehicle, it really goes off the pad fast, relatively.

Delta IV crawls off the pad, just crawls. We were like the heaviest payload they'd ever flown. They were offloading propellant to make it light enough for us to be able to even get off the pad. It just crawls off the pad. Between the fact that it's coming off the pad so slow, to somebody who's used to watching Shuttle, and this big fireball erupts out of the bottom of it from all the excess hydrogen burnoff.

My husband, he's standing at the causeway with my daughter. It has the countdown, and it says it's launching. Then you see the initial engines light off and everybody goes, "Yay." And then whatever the appropriate period of time it would have been for Shuttle to make progress, that you'd have seen it was launching, it did not move fast enough. The people were like, "Oh." And then "Oh, yay," once it pulled out of the flame. He said, "That flameball came up the side of the vehicle." He said, "A lot of people were like, 'Oh, no.' You told us what to expect, so we just waited." It was a little angst-inducing for people that weren't used to watching a Delta IV Heavy launch.

That went really well. Then people hold their breath until the separation, and you've got the upper stage firings. Those are always reliability anxious points. Then the rest of the mission went pretty seamlessly. Everything went smoothly. We're watching for radiation upsets. It doesn't really happen. Yes, there was onesie-twosie things, but nothing like what we thought could have happened. The systems recovered, no problem. We went through the whole mission, and I would say really until we got to the point—I didn't even really have that much concern about the capsule separating from the upper stage. I'd seen the development work on the pyrotechnic devices. I felt like they were very reliable, so I wasn't too particularly concerned about that.

The process of going through the plasma field and waiting for the vehicle to emerge, there's just nothing to be said about the angst of having the vehicle in loss of signal. For the minute or minute and 30 seconds that you're sitting there, and you've got nothing coming off the vehicle, that definitely for me was the most stress. Once you got past the initial launch itself, that was the most stress-inducing. You hear people talk about Apollo, waiting for the vehicle to come out of loss of signal and then the cheer that erupts as soon as they regain communication with the vehicle. It was just like they said it was, which was pretty cool. You could definitely feel that sense of camaraderie or parallelism with what they must have experienced when they had Apollo.

By then it's so fast. Then it just goes boom boom boom, and the chutes are out before you can even think too much about it. Then once the chutes are out, you're really home free no matter what little things might happen like oh, the uprighting bags don't work the way they're supposed to. You're really pretty much home free, and you've made it. Once the chutes are out, it's all good. It was great. It was everything you could have imagined it was going to be after all

that work. Then to watch it fly, and fly so successfully, I think everyone was quite frankly shocked.

People would say to me, "Was it really as good as it looked?" I'd be like, "Yes, yes, it was. Yes, it was." We'd like to chalk it up to the fact that we're so brilliant. We did the work we felt like we were supposed to do to make that happen, but I don't think any of us could have imagined we would have been so lucky that nothing unexpected really happened. It was good.

ROSS-NAZZAL: Looking back, what do you think was your most significant contribution to EFT-1?

KRAMER WHITE: Golly, let's see. I wish I had some really brilliant technical thing to tell you. I would say my personal contribution probably these days is as much leadership as technical anymore. Keeping the team motivated and on point and moving despite stuff like 2010. I would say, in terms of my personal accomplishment, being able to lead that team and remove barriers so that they could do all those things that they needed to do to make EFT-1 successful. Keep them sheltered from some of the crap that was such a huge distraction from them being successful. I think those are probably these days the contributions I get to make.

I did get to work on some fun technical stuff. They humor me every once in a while and throw me a bone, let me work on some structure stuff. It's really got to be mostly about keeping the team focused so that they can be successful, which isn't very specific. I'm sorry I can't be really more specific than that.

ROSS-NAZZAL: That's okay, and it's very similar to what Mark Geyer said this morning. What about your most significant challenge as you worked on the Orion Program through EFT-1?

KRAMER WHITE: Aside from the political challenges we've already talked about, the technical challenges. The heat shield was a constant challenge for us and was one where I felt like with my background I was able to help the team technically. I always think of things like the heat shield.

At one point during the build we cracked the pressure vessel. Both Marks used to laugh because they were sitting there, their heads in their hands. Just the most horrible thing that could possibly happen would be to crack the pressure vessel. My reaction, I'm a structures guy, so I'm like, "Oh, that's awesome. I'm going to the Cape, I'll see you later." I go running off to the Cape to go work on the pressure vessel. They said, "Man, we haven't seen you look this happy in years." I said, "Well, it's because I know it's bad, but it's something where you feel like you can contribute and make a difference and work with the team and get them through it."

Things like that occasionally happened that I was personally able to help them with. The majority of the time it was really just more, "Hey, it's okay. That's a good decision. Maybe you don't have all the data, maybe you would like more data, but you're not going to get more data." So helping them make decisions and helping them move through that process. Those are the kind of accomplishments I get to chalk up these days.

That's good. It's good. If I feel like I can help them make decisions and make progress, then I feel like I've had a good day at the office.

ROSS-NAZZAL: We talked to Don [Donald E.] Reed a couple weeks ago. He was talking about all of the different tests that had originally been scheduled for Orion and then as time went by there were fewer and fewer of these tests. There was Pad Abort 1 [PA-1] and then there were other tests that were planned. What was your involvement in those decisions to decide you didn't need all of those tests to be run? What impact did budget have on those decisions?

KRAMER WHITE: Obviously as a part of Mark's senior management team, I was involved in all those decisions. Yes, I think the original test sequence was six abort tests, two pad aborts, and maybe at one point four ascent aborts [AA]. Very much modeled on Apollo flight test precedent. Over the years that we were with the Program the cost of running that many tests became overwhelming, and the competition between those tests and the mainline flight program for resources became a problem. The Program was constantly asking Engineering to go back and say, "Do we really have to do, do we really have to do, do we really have to do."

To a great extent, I think Engineering would like more tests, would like more data. We always like more data. That's a joke, but it's true. We always like more data. I'm never going to say no to somebody who wants to run a big flight test, plus they're fun. We looked at where we were in terms of our understanding, and what we were trying to prove or validate in those tests, and felt like we were on pretty solid ground with the data we had. PA-1 was a big success, validated a lot of models and analysis.

I'm sure Don would have talked to you too about AA-2, the last of the ascent abort tests. We cut one, and then we merged the remaining two into a single test. Originally we envisioned doing max dynamic pressure and Mach 1 as two separate test points. For Orion they happen to be pretty close in time in the ascent trajectory, so we merged them into a single test, which is

AA-2 now. I'm a big proponent of AA-2, and we've had to fight to even keep it in the baseline, because a lot of people feel like "Well, our models are good enough. We can do everything by analysis, and we don't have to validate this capability."

I know I think I speak for a lot of people in Engineering, and I know I speak for Don when I say we feel like it's our job to demonstrate that this vehicle has robust abort capability. It's one of the fundamental tenets of going from a winged vehicle to a capsule, to be able to provide robust abort capability in case something went wrong. Those ascent abort and pad abort tests are important. While we understand the Program's constraints on budget, just couldn't tolerate cutting AA-2 and even in the last couple years had some pretty significant push and pull with the Program on trying to keep it on schedule.

I worked with the Program recently on an initiative over the last couple years to move the AA-2 work principally to a government function rather than contractor function. It's more easy to fence those resources and fence that work on the government side and protect it and ensure that that test gets done. Really important that that ascent abort test get done. It's under constant attack, because when you look at the budget it's an obvious source of money. When your main objective is EM [Exploration Mission]-1 or EM-2, AA-2 looks a bit like a detour or looks like something that's sucking money and resources off that main line, particularly when it was at Lockheed. I used to call it the piggy bank that they would take money and resources from when they ran short on the mainline Program. AA-2 became the piggy bank. Pulling it off Lockheed's plate and putting it over on the government side, it's a little bit easier to protect it, which I think is important. Those guys are making great progress, and I'm looking forward to seeing them fly here in a couple years.

ROSS-NAZZAL: I had no idea how much those tests cost. Don told us, and I was like, "Wow, that's amazing."

KRAMER WHITE: They're expensive. We do not live in an Agency anymore that just goes out and chunks boilerplates off the back of buildings. We just don't do that anymore. It's very expensive to do stuff.

ROSS-NAZZAL: That's obvious, all that stuff we learned about in the '60s. It's amazing. Just one other quick question for you. Mark Geyer said that the Orion Program learned to persevere. Do you agree with that statement?

KRAMER WHITE: Oh my God, yes. I laugh about, "Head down, keep coloring." That was the mantra. "Just don't look. You don't want to know. So just keep coloring, don't look up. Hang on, I don't care what other people are saying around you. Just hang in there. If we hang on long enough and do good work, someone will notice."

Mark left that legacy on Program, and I think it still exists to a great extent today. They worry about the election in the fall, and they worry about NASA and Orion. You got to tell them, "Just don't worry about it. You can't control it, first of all. So don't worry too much about it. We'll deal with it. You just keep your head down and keep coloring and make progress. We'll be measured by the progress we made."

Persevering through what seems like it can't be overcome, but that's a good way to describe it for sure.

ROSS-NAZZAL: I thought it was an apt quote we came across. We've been asking folks. Everyone seems to agree. We haven't found anybody who disagreed with that statement. …

There's plenty more to talk about obviously. We're just hitting really what I feel is barely the surface of things. I don't know if there's anything more you'd like to talk about. Hopefully we'll have another opportunity to talk if we're around in the fall. But I don't know if there's anything else that you feel like we might want to talk about about EFT-1 or anything we didn't.

KRAMER WHITE: I'm kind of talked out for today. But yes, I hope it works out. I'm happy to do round two if you wind up with the time and the funding to do it.

[End of interview]