NASA JOHNSON SPACE CENTER ORION ORAL HISTORY PROJECT
EDITED ORAL HISTORY TRANSCRIPT

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INTERVIEWED BY SANDRA JOHNSON
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JOHNSON: Today is June 22nd, 2016. This interview with Scott Wilson is being conducted for the NASA Johnson Space Center Orion Oral History Project. Mr. Wilson is speaking with us today by telephone from the NASA Kennedy Space Center [KSC] in Florida. Interviewer is Sandra Johnson. I want to thank you again for joining us today and for agreeing to talk with us.

WILSON: Thanks, Sandra. I appreciate the opportunity.

JOHNSON: If you would, to begin with, start by briefly describing your background with NASA and how you first became involved with the Orion Program or the Constellation Program at the time.

WILSON: I started with NASA actually in 1991, and I started with the [Space] Shuttle Program. I worked the Data Processing System [DPS], and eventually main engines. I was always fascinated by trying to figure out how to design things to be better. That led me into the Shuttle upgrades world for a little while, as we worked on that.

As the Shuttle Program ramped down, my fascination with how to make things better led me into taking a detail up at [NASA] Headquarters [Washington, DC] back in I think it was 2005. It was a really interesting time. It was a time where we were trying to figure out what were we going to do to replace the Shuttle. I actually went up to work under Admiral [Craig E.]

Steidle, who had come over from Joint Strike Fighter [Program] to work on initial requirements for whatever this new thing was going to be, and spent a lot of time there working that. We started doing a lot of trades trying to figure out what is the next spacecraft. Is it a Shuttle-like vehicle with wings? Is it a capsule? What's its mission? Where should it go? How would you process it? What does the rocket look like? Lots of different trades, and using those trades trying to figure out the requirement set.

About partway through my detail, we ended up changing [NASA] Administrators, and Mr. [Michael D.] Griffin came in at that time. He started what we called the ESAS [Exploration Systems Architecture] Study, which was trying to figure out those same things, but took a little different angle on it. I was actually part of the support to the folks doing that study there. It was a very interesting time at Headquarters, lots of changes going on, but it was pretty exciting because the work we did there and the requirements we generated really set the stage for what became Exploration, and turned into the Constellation Program, and then of course when that morphed into the Orion work that we're doing today. That's how I got involved in it.

JOHNSON: How long were you up at Headquarters?

WILSON: It was a one-year detail I did. I was a Kennedy employee at the time when I went up there, and had the chance to do that. When I came back to Kennedy I began working on some of the requirements for the ground systems that would actually support that architecture that we put together while I was at Headquarters. It was nice to be able to be part of the implementing side of what we had started at Headquarters.

Shortly after that position, the Orion Program was just starting. We had had the contract out. Matter of fact, when I was at Headquarters we were working very closely with the folks putting together the proposal for what would become Orion. Once I got back to Kennedy and that was awarded, we talked about bringing the factory operations to KSC and needing Production Operations basically to oversee building the vehicle. So I applied for that position and eventually got it and rebadged to be a Johnson Space Center employee to oversee that work.

JOHNSON: That was around 2007?

WILSON: Yes. I think it was 2006, 2007. Skip [Caris A.] Hatfield was our Program Manager at the time, and Skip hired me in. I thought it was a job to build spacecraft, and it turned out the first part of it was building the buildings and all the factories and understanding what it takes to build spacecraft. This included building the factories at the O&C [Operations and Checkout] Building here at Kennedy, some work we did in New Orleans [Louisiana] at MAF [Michoud Assembly Facility] and Plum Brook Station [Sandusky, Ohio] and other places.

That was the first phase of it, building buildings. Then of course very rapidly on the heels of that we started building our first spacecraft.

JOHNSON: You were actually a JSC employee at that time but you were working on making sure that this ground structure and these buildings for processing were in place at all the different locations that they would need them. Is that correct?

WILSON: Exactly, yes. Knowing that we needed those buildings to be able to build the spacecraft in and to test them. That was really the first phase. One of the really nice things—we always said it was a nice thing and a curse at the same time—was we had a blank sheet of paper. We could design our factory from the ground up however we wanted it to be, which was good and bad. It didn't exist, so it was a lot of work, but we got to make it what we felt it needed to be to build the spacecraft the most efficiently.

JOHNSON: Talk about some of those changes. When you went back initially to KSC the ground systems, you were taking a look at that. I know that things did get changed with the ground systems at Kennedy and with the buildings. Just talk about maybe some of the specific changes or things that come to mind that you worked on during that time when you were a JSC employee to make sure that those things were ready for the next program.

WILSON: Probably our biggest challenge, the one we had right out of the gate when I came on board with Orion, was we knew we had to build spacecraft. We had talked about where we would build those. Historically spacecraft were assembled and built different places in the country and eventually transported to the launch site for final checkout and integration. But we were at a unique place where the Shuttle workforce at Kennedy was ramping down, so there was a lot of skilled workers available.

The O&C Building at Kennedy was no longer needed, and so the Center was considering what to do with that. Do they demolish it? One of the first big decisions we made as a program in terms of production was to put the production of the spacecraft here at Kennedy Space Center

in the O&C Building, which was again historically very different from the previous models where only final assembly was done here only.

The state of Florida worked with the Center to provide some incentive funds if whoever won the Orion contract would move their production here. As we know now, Lockheed Martin won. They took advantage of that. We had about a $55 million effort to refurbish the O&C Building and to turn it into that factory that we use today. That was probably one of the big decisions early on. I think it's really paid some dividends by having the factory at the launch site. We were able to capitalize on the workforce that was here. It was very skilled coming off of Shuttle. We were able to capitalize on a lot of the infrastructure that Kennedy Space Center had and things that are needed to support production. Examples are machine shops where we didn't have to stand up our own shops. We could essentially buy services from the infrastructure at Kennedy. I think it's had a lot of benefits of doing that.

Probably one of the other early on decisions we made at the Agency was trying to figure out, as we were standing up Constellation, what Centers would work on what programs and how the work would be distributed among the different Centers. NASA Glenn [Research Center, Cleveland, Ohio] had Plum Brook Station, which had what we called the Space Power Facility there. It was a building that was originally built way back I think late '60s early '70s to test nuclear spacecraft. They had a large vacuum chamber there and some other test capability.

We needed a place that all the elements of Constellation at the time could be tested in their environments. By all those elements I mean not just the Orion spacecraft, but the Ares rocket components and the Altair lander components. We decided to refurbish the Space Power Facility at Plum Brook Station to be our one-stop environmental test facility. We had a fairly

significant effort there to build a large vibration table, a large acoustic facility, and upgrade the vacuum chambers and provide quite a bit of that test capability there.

That has since been mostly finished. We're actually using that today. We've used it for various aspects of Exploration Flight Test-1 [EFT-1] and we're currently using it to test the European Service Module's Structural Test Article. Those are probably the most significant early facility decisions we made.

JOHNSON: You were talking about the budget. You had the budgets to make those changes. We can talk about when it changed from Constellation to Orion. I know that the budget has been relatively flat since that time. Was there more to work with early on with the changes that you had to do with the facilities? Or was that something that you felt there was enough to do what you needed to do? Or were there some hard decisions or decisions that you had to make that were affected by the budget?

WILSON: A couple of ways to answer. I guess in my opinion I think when you first start a program you're in a place where you have plans in place and you budget for things. You don't always get the budget you want in total but you're able to do most of the things you want because it's a honeymoon phase. You haven't really gotten into it enough to find the problems and the places you're going to have to go spend more money on.

Early on I think we planned to do the things we needed. We did run into issues both at the O&C and at Plum Brook where we found things that did drive costs a little more. At the O&C, it was a building built in the '60s. It turned out if you could make something out of lead,

PCBs [polychlorinated biphenyls], and asbestos, they did. Those kind of things took us a little more remediation (and budget) than we initially planned.

But, what we were able to do was take the budget cap we had and try to adjust requirements. It really forced the team to be very creative in how we solved problems. I think that's a story that's carried on through. It's a theme through all of Orion. Budgets maybe were a little better back during the early Constellation days. Now with the flat budgets we really have to try to figure out how to do a development program, which normally is a funding hump, we have to do that in a flat budget. It's really driven, I think, the Orion team in general to find very efficient, very creative ways to do things that haven't maybe historically been done that way.

In general I think it's really worked out well for us. One of the changes after Constellation, when things got a little more scarce, was it really forced us to become even more efficient. In some ways it was a good thing for us. From the government side we have an inherent job to do insight/oversight of our contractor Lockheed, but we found ways that we can do that by also producing products ourselves jointly with Lockheed or for Lockheed. That gives us insight to a level that we never would have gotten without it. It also produces valuable products, so it's not just watching somebody work. Those are little examples of ways we found to do more with less that I think have really forced us to be efficient.

JOHNSON: Let's talk about that time period. In February 2010 of course it was canceled when the President made the announcement that it was going to be canceled. Then the budget, once it was approved in April 2011, then the cancelation became effective. There was a period of time in there, a few months, and people were still working on Constellation, but they knew the program wasn't going to be there. If you can, talk about what it was like during that time period

and what you were focused on or the area you were working in was focused on, and how that transitioned into the Orion Program.

WILSON: That's a great question. Personally having started this thing like I said back with requirements and "shall statements" and seeing it all the way up through where we were before the cancelation, seeing actual vehicle designs coming out and beginning to set up the factories and start building spacecraft, to go from that excitement of seeing it through to what basically was a pretty big surprise to most of us. I think it was less than 24 hours maybe before the announcement when we found out about the cancellation, We really felt morale-wise like the rug had been pulled out and nobody understood why.

There were a couple things going on. One is, as you can imagine, morale was at an all-time low. I had never seen it that bad in NASA. It's always been a place people were very excited to work, and couldn't wait to tell their story to their friends and family. It went from that to just a very gloomy place.

I think we could have just stayed in that place and dwelled in all that and let the program go. But, as you mentioned, we were in a pinch for a little while. Congressionally we were by law required to continue, and by order of the President through the Agency we were asked to stop. During that timeframe we had funds that we needed legally to spend, and what we decided to do is—and it's a big credit to Mark [S.] Geyer and [T.] Cleon Lacefield, who were our NASA and Lockheed Program Managers at the time—they really helped us all rally around if this is going to be our last year of the program, we're not just going to roll over. We're going to do the best we can with the money we've got to provide something really good for the country.

That was really where the Exploration Flight Test-1 concept got started. We really very quickly tried to focus the team away from dwelling on "Hey, you're canceled," and more towards "Let's do the best we can and show folks what we can do. If we continue to do good things, maybe good things will happen."

We really focused hard on EFT, and in hindsight I think that was exactly the right thing to do. It was the best use of our taxpayers' money, and it was the best focus I think for the team. Probably the most important thing I think that we did in Orion, to keep the team in progress moving forward. I don't know if that's a good explanation or that's what you're looking for there, but that was my insights on that whole time period.

JOHNSON: During that time period you said that you started focusing on the EFT. Did everyone had the sense that Orion would continue?

WILSON: No. I think we weren't sure. There was a tremendous amount of uncertainty I think. But what we all jelled around was even if we're going to be canceled, let's do the best we can. NASA is not about quitting. We have the money. We've got a responsibility to use it wisely. Let's do the best thing we can. We put our heads together trying to figure out what that is. I think Exploration Flight Test-1 is what came out of that, that we could at least gain some test data that's certainly going to help our program if we do continue, but it also would be good data that uses the money wisely for any other program that might continue after us if it wasn't us.

I don't want to give the sense that it alleviated all the uncertainty. There was a tremendous amount of uncertainty. I think as you know it fluctuated even through that by different policy things that were done. Originally we were just flat canceled. Then we were

going to maybe be a [International] Space Station [ISS] rescue vehicle. We'd maybe build one article and put it on Space Station in case you needed to do a quick return. Then eventually as you know now we've morphed to focus on the deep space part of things with Commercial Crew & Cargo [Program] filling the space to ISS and low-Earth orbit.

It was a really tumultuous time. Lots of uncertainty. But again, I was really really proud of the team that we got and for the way we, in spite of all that, pulled together and really did something great at a time where we could have taken an alternative and just stopped.

JOHNSON: Were you back at KSC by that time or were you still working at JSC?

WILSON: I was. When I went to JSC—I say went to. I was a JSC employee. I think early on when we decided to have a Production Ops [Operations] office and we knew production would be at Kennedy, Skip Hatfield, our Program Manager at the time, wanted to make sure that the person leading production really was accountable to the program. So, I rebadged from a KSC employee to a Johnson employee, but I actually remained living in Florida. I did that right up through the cancelation of Constellation. At that timeframe there was a person in the reverse situation who was a KSC employee who had lived his whole life at Johnson who was supporting the Ground Ops Program at the time. What they had us do was do a badge swap, where I got a KSC badge back and the person in Houston got a JSC badge just in case the programs got canceled so we weren't going to have to move around.

Of course after Orion came back after Constellation, I had a lot of discussions with Mark Geyer at the time about whether he felt the need for me to rebadge, and he didn't, so I continued to do the same job, just with a KSC badge.

JOHNSON: That is when you became Manager of Production Operations at KSC?

WILSON: Right, yes, when I got my JSC badge that first time was when I became the Manager of that.

JOHNSON: It was just the badge switch then.

WILSON: Yes, it was just a badge switch. So I've had that position both as a JSC and KSC employee.

JOHNSON: As you mentioned, I think in May 2011 they announced the MPCV [Multi-Purpose Crew Vehicle], which became Orion, so that work again changed. I know like you said there was talk of using it for different things, and then it finally jelled into one vehicle that could be used for multiple things. If you want to talk about just that time period once we knew we were going to have Orion and up through the ability to fly that EFT-1 mission.

WILSON: Yes. Again, coming out of the Constellation morale was down. We were focused on EFT. We had lots of uncertainty but we tried to focus on EFT and move forward just really not knowing what our mission would be, if we even would have a mission.

I forget the exact timeframe, but somewhere in there the President actually came down here to the O&C Building, which was a really very interesting time. He gave a speech here where I believe it was in that speech he said we would become—I forget the exact words but

essentially—the rescue vehicle. That gave a little bit of hope to the team. But for a team that really was trying to design deep space vehicles for missions, exploration type activities, it was a glimmer of hope, but it wasn't really what we all wanted to do and thought was probably the best path forward.

Then of course eventually we continued on building the EFT. From a production standpoint we were very focused on design and production of that vehicle. We also did a lot of work behind the scenes in the requirements areas, where as what was being proposed was the MPCV [Multi-Purpose Crew Vehicle], as opposed to the CEV [Crew Exploration Vehicle] that we had during Constellation, and as the needs for what that MPCV would look like, we did a lot of efforts to map our current capabilities of what Orion could do against those new requirements. They mapped very well, which was really a testament to our designers and our early requirement set to try to make the most versatile vehicle that we could that could serve many missions.

If you recall during Constellation our mission was—we actually had two. We were the vehicle that would take astronauts to ISS and low-Earth orbit, and we would also be the vehicle used for deep space exploration to the Moon at the time. What we ended up morphing into as MPCV was really that deep space vehicle, so going beyond low-Earth orbit, to the Moon, Mars, and of course the asteroid mission that's been proposed. Then the gap from Earth to low-Earth orbit was to be filled by Commercial Crew & Cargo.

So our mission changed a little bit there. I think it was a good division of those roles. I still get asked today. Matter of fact, in the interview I did just a little while ago I got asked whether we see Commercial Crew as our competition. The answer is really no. I think it's a division of where Commercial Crew fills a space that's good for them to do and it lets NASA

really concentrate on deep space and exploration, which personally to me I think is really where NASA's mission is. I probably diverged a little bit from the original question.

JOHNSON: No, that's good. You did talk about the spacecraft itself, Orion, a little bit. I know I've heard other people mention this and I've read articles where people talk about "Well, it just looks like Apollo, there's nothing new here." Do you want to just talk about what you feel are the major differences? Not necessarily between it and Apollo, but some of the upgrades, some of the newer technology that's been developed. It may be even with the ground systems or the SLS [Space Launch System] or anything that you've been involved in that is affecting this new program and making it truly a twenty-first century program.

WILSON: It's another great question. It's one we get asked a lot because if you don't know a lot about the spacecraft, it does look like we've taken a step backwards. People always ask about that.

To answer it, I usually go back to again the time I had at Headquarters both under Admiral Steidle at the beginning and then under Mike Griffin, where we were trying to decide what does this vehicle look like and what is its mission, what are its requirements. A lot of the early concepts we had ranged from things that looked more Shuttle-like with wings and more lifting bodies to capsules at the other side of it. We spent an awful lot of time doing trade studies back and forth to see what we should use.

At the end of the day it was really dictated by the mission and the physics of it and safety. A winged vehicle, as we saw in the [Space Shuttle] *Columbia* [accident, STS-107], if you lose controllability of the vehicle and you can't control it and you head into the wind at the wrong

angle, you lose the vehicle, and you can't control it, and the vehicle will break up as unfortunately we saw. A capsule design, if you lose controllability, you're still going to land, like a badminton birdie. You may not land where you want to, but you do a ballistic entry, and you end up landing, and the crew can typically walk away from that. That safety feature alone was a big sway in those trade studies.

The other thing, probably less safety-related, was mass and how it relates to the mission. If you go to low-Earth orbit like Shuttle did, and most of your time is spent just in low-Earth orbit and transitioning through the atmosphere up and back, the mass penalty for carrying wings with you, it's significant but it still allows you to achieve your mission. When you go to deep space the penalty for every pound of stuff you need to take with you really increases quite a bit. I've heard figures ranging from for every pound you take to lunar orbit it's about 5 to 10 pounds of support things you need to take. That support stuff could be structure, propellant tanks and extra fuel. There's maybe as high as 10-to-1 penalty for weight that's on a spacecraft for deep space missions. Taking wings with you really was a huge mass penalty for something you didn't use except for the last couple minutes of reentry coming back in.

Those things at the beginning are I think some of the primary drivers that drove us to a capsule design. Then once you go to a capsule design, the physics of it determines the angle on the capsule and what that capsule looks like. It turns out physics hasn't changed since Apollo, so it drives you to a basic shape that looks very similar, but I think that's really where the similarity ends. The spacecraft itself is tremendously different other than the shape of it. Unfortunately that's the thing most people see.

When you get down into the spacecraft itself, it's quite a bit bigger. Apollo, if you recall, was sized for three people. Then when you got to lunar orbit, one person had to stay with the

vehicle and two could go to the surface. We always joke that we'd like to have seen how they drew the short straw to see who got to stay and who got to go to the surface.

Orion is actually sized for deep space missions for four people. Originally under Constellation we were sized for six people to low-Earth orbit. We've maintained that size, we just fly with less seats for a deep space mission. Then once you're in a mission, the vehicle is autonomous enough now where it can control itself and stationkeep itself to where if you were doing a lunar surface mission, all the crew can leave, and the spacecraft is now sophisticated enough to take care of itself.

That points to a couple things. The size differences and the advances in computing power as everybody knows from where we were in the '60s and '70s and even the '80s with Shuttle to now with cell phones. It's orders and orders of magnitude more powerful in terms of what it can do and the autonomy that it has both in our software and our avionics systems.

Probably other trades we did that led to where we're at is there's always a trade between how much heritage hardware you want to fly versus new things that you want to add. Heritage hardware, things that exist today, give you a schedule advantage to maybe be able to field things sooner, but maybe don't have all the capability as if you designed a brand-new system. So we did a lot of trades on things.

You'll find places we maybe leveraged off heritage things, like the main engine on the Service Module has some heritage into the Shuttle OMS [Orbital Maneuvering System] engines. But again, it's a more advanced version; we've done a lot of tweaking to it. Similarly the Shuttle tiles were obviously used on Shuttle. We use a much more advanced variant of those to cover our backshells on the Crew Module.

Lots of advances. Other advances are in life support systems. Power generation is a big one. The Apollo used fuel cells. Fuel cells take commodities, hydrogen and oxygen, and you're limited in the amount of power you can generate based on how much fuel you take with you for the fuel cells.

In Orion we use solar cells now. The advances in solar array technology has increased so much that we're able to use solar cells. We actually get more power and we can continuously generate that power with no need for commodities. That helps us both operationally in terms of we don't have to service things on the ground, but also operationally in flight because we have that power available all the time. Those are probably a few examples.

JOHNSON: As we were talking about the budget earlier, and once it became Orion, and then the budget really did flatten out, some of those things that you were talking about how you looked at heritage hardware, and I know with the SLS they used some Shuttle technology in the engines, trying to reuse some of those things so that you can keep the cost down. Can you think of any other examples where you went back and looked at those historical resources? Or any other ideas about how you all were able to keep that budget more flat, as we're building a program, as you mentioned earlier, usually you have a hump and then it goes to operations and the budget becomes flat.

WILSON: I think the hardware ones that I pointed out were probably the most significant ones that I can recall. Again the use of the OMS engine, use of Shuttle heritage tile. Again all those advanced versions of things. Thrusters are loosely based on Shuttle thrusters. Some of the similar technologies but with improvements there.

Those are the main hardware ones. There's facility things like I mentioned early on reusing the O&C was a big deal for us. Repurposing the Space Power Facility at Plum Brook Station was one. Retooling MAF in New Orleans was another one where we were able to capitalize on equipment investment that was already at MAF in terms of friction stir welding that was used for the Space Shuttle external tank that we now were able to capitalize on as well. There were things both in the design of the vehicle as well as how we would build and field and test the vehicle.

I think the other thing that probably isn't as tangible as let's say a facility, a factory, or the vehicle is the way we do things. I think Orion is—I'm not sure I'd say unique—but we did a lot of soul-searching after Constellation to figure out how can we be more efficient, and what can we do different. We've tried to really challenge blind requirements.

There's a lot of tendency sometimes in an organization as big as NASA, or frankly as big as our contractors are sometimes who follow NASA, to say, "Hey, this is how we did stuff, and so we should keep doing it this way." I think in Orion more so than any other place I've worked we've really tried to challenge those processes and things to make sure that they're valid for what we're doing. Don't just use a process that's been around forever. Let's see if it fits what we need and see if there's reasons for these requirements and try to do things differently.

The other thing we've done more processwise—again in Orion I've seen it more than other places—is we tried to structure decision making in a way where we try to push the decision making to the lowest level that it can be at. If there's a very detailed design decision between two equal ways of doing something or designing something, we would try to push that into the IPT [Integrated Products Team] or even to the design subsystems below that. Then what we do

is those decisions are made there, rather than bringing every decision up to boards and panels at the program level, which really just slows things down and costs quite a bit of money.

To balance that out, when you push that decision making down, you want to make sure that you're not relying on a single individual in cases where you could have safety issues or design flaws. We always have what we call a reclama path to the next higher level where if somebody at the lower level disagrees with a decision, there's always that path to raise that up to the next higher level. That can go all the way up to our Program Manager and beyond if necessary.

The other thing we do, which I think is pretty traditional in NASA, is we also have the check and balances of the tech [technical] authorities at every level as well, those being Engineering, S&MA [Safety and Mission Assurance], and Health and Medical. They're always there working with us, but independently, to be able to call foul if we made a bad decision.

I think going back to your question, I'd bucket it in three places I think we've tried to change to adapt to the flat budgets. There's some of the decisions we made vehicle wise, some we've made facility wise, then of course the process things within Orion of how we make decisions and how we do designs. Does that answer your question?

JOHNSON: Yes. I think it does. At Headquarters they have the Exploration Systems Development [ESD] Division under HEO [Human Exploration and Operations]. It's more overseeing over all these different aspects, the Orion itself, the SLS, the ground systems, and making sure all of that works together.

Since you're the Manager of Production Operations at KSC, do you work closely with ESD at Headquarters in their function for cross-program system integration?

WILSON: Yes, we work some. Probably not as much as maybe some of the other CAMs [Control Account Managers]. The Vehicle Integration [Office] VIO CAM under John [A.] McCullough, they're probably our primary interface for the up and out in general from the program itself. They do more of that integration work there between the two programs.

What I will say is the job that I've got here as Production Manager being resident at Kennedy lends itself to a lot of interaction with GSDO [Ground Systems Development & Operations] just due to the fact we've got the vehicle here and GSDO is the customer that we hand the vehicle off to for integration with the launch vehicle later.

That proximity has had a lot of benefits in that we can do a lot of cross-training between those two programs. A lot of issues or questions that might have had to bubble up through program-to-program interfaces or up to ESD to be solved, a lot of times we can solve those things locally, just by nature of the proximity of an Orion Program that's building their vehicle at the launch site where GSDO resides. That was another one of those considerations to putting the factory here.

You might have been asking this too. Under Constellation that ESD model was very different. There was a very large integration group at Headquarters that was in charge of doing the integration across the three projects at the time. Again, after Constellation we became three independent programs. There was a lot of discussion about do we need a large integration group to integrate across the programs or are there some ways we can change our process to be more efficient. Again I'm going back to those flat budgets, what can we do better.

The decision was made to share that integration role across the three programs. We actually call them our sister programs between SLS, Orion, and GSDO, where different elements

within each program help to do that integration function, but they're also part of the program. I think the presence at Headquarters of the people who do integration is much smaller now than it was in Constellation. I think it's working very well, and I think it's a significant cost savings as well. It's another example of trying to do things different, and really pushing the boundaries of how we do things to save cost and be more efficient.

JOHNSON: That's part of that multicenter program management model that you seem to be following.

WILSON: Absolutely. I know one of the questions you were interested in is how is that working for us. Personally from a production standpoint I think it's been fantastic. Just in the production group that I oversee on the NASA side, we have Kennedy folks who help support us locally with the build activities here at Kennedy. I've got [NASA] Langley [Research Center, Hampton, Virginia] folks that help us with the integration of MGSE [Mechanical Ground Support Equipment] and tooling, and also work with the Langley folks doing water drop tests there.

I talked about Plum Brook Station and I've got a pretty large group of folks that support production ops out of Glenn Research Center that support the facility builds at the Space Power Facility, support the testing we do there, and also support production activities with the European Space Agency out of Glenn Research Center. They all work for Production Operations in the program.

By having the ability to cross Centers for how we staff and populate our teams, we're really able to get the best of the best and get the people with the most experience in a certain area as opposed to maybe just the most experienced person we might have at our Center. I think it's

been a tremendous strength of the program. It's again another strength of Mark Geyer and Skip and others who really allowed us to do that.

JOHNSON: Let's talk about the buildup to EFT-1, and what was going on during that time. When the Orion spacecraft actually arrived at KSC, and as you said in the O&C, to start putting it together, during that time period what was going on?

WILSON: I mentioned early on when I first started I thought we were going to be building spacecraft. Of course we were really building factories for a couple years to try to build the facilities that we would need and all the tooling to be able to build spacecraft.

We built a ground test article early to get some design data. So it helped ring out how you build spacecraft, but it was really just structural. EFT was really the first build. In a lot of ways it was a pathfinder. Of course from flight test objectives and the spacecraft itself it was a pathfinder, but from a production standpoint it was a big pathfinder for "how do we build spacecraft." Nobody had built a human-rated spacecraft since the Space Shuttle. Most of the people who were involved in those initial decisions weren't with NASA or our contractors anymore. We had a few we'll call graybeard folks that we would pull on for consulting from time to time, but it was really the first time.

I would say we were probably a little naive at the beginning. I think we went from building buildings, and then we organized, and we thought we had everything perfect to build a spacecraft. We jokingly would say we were waiting, we got our very first part in, and we thought we were in production, and then somebody reminded us that it takes two parts to build anything, to put them together, before you're really assembling anything.

We waited for our second part, and it turned out it wasn't the one that bolted to the first part, so we were still waiting. We were so excited. We were showing everybody this big box in the O&C that had this one part in it because we were finally getting to build the spacecraft that for years we'd been working towards and designing and working requirements for.

As the parts began to come in, we really figured out "Wow, this is what it really means." No matter how good you are at planning things, when reality finally hits you and you really start doing it, there's a lot of things you got right, and you're thankful for that, and there's a lot of things you didn't get quite right that you have to tweak.

The Exploration Flight Test-1 build for us was a several-year effort, and it started in New Orleans with trying to weld the major parts together. At the time we had 32 different parts that we had to weld together to make the crew module, with just the pressure vessel, which is the center piece of it. We were fielding brand-new welding systems and new technologies on the welding, and struggled through that. Finally got it working and developed. Fast-forwarding over time now, we've learned how to do that, with just seven parts, so we learned quite a bit, but at the time it was a big challenge.

We got that piece here at Kennedy and really started trying to do all the other things on it and had lots of issues in learning everything. I mentioned earlier that the production was a blank sheet of paper and we got to design everything, but some simple things that you don't think about like, "How do you receive a part and make sure that you've checked everything out and that it's all perfect and get it into the right paperwork systems and receive it and issue that work to the floor?" Those are all things we had to work through, which doesn't sound particularly exciting, but they were all part of how you build this system that allows you to build spacecraft.

Throughout EFT I always say we divided that flow into three epochs. The first was we were trying to get our processes in place, and figure things out, and get started. Parts were trickling in where we really weren't getting them all as quickly as we thought, because vendors were going through those same issues. We eventually got through that part and we had all the parts here, and continued with production.

Then we got into the second phase of it. I call that some of the "problems of our own making." Things that we thought we had really well understood, like how do you weld propulsion systems and environmental control systems into a vehicle in a very clean environment. We ran into lots of issues with maintaining cleanliness and welding those in. Took a lot of learning to figure that out.

We got through that, and then the last phase of it was really the nicest, which is where I think we finally hit our stride and we really started hitting all our milestones, and everything was going very very well right up through delivery. It took us those first two-thirds of that flow to really learn how to build vehicles and to make it efficient.

Then of course over time we've applied all those lessons learned into what we're doing now for EM-1 [Exploration Mission 1]. It's funny. As you build it, I remember somebody asked me—I think we had some press folks in town, and they asked what I was thinking when we rolled the vehicle out of the LASF [Launch Abort System] Facility fully stacked. It was nighttime, and all the lights were shining on it. It was hard to describe it, but there's a pride in what the whole team accomplished. Nobody had done this in decades. There was also thinking back to those first days back up at Headquarters trying to figure out does it have wings, is it a capsule, what does it look like, how big is it. To be able to be part of this from words on a paper to seeing this thing roll out was just amazing.

JOHNSON: Yes, I bet that was amazing. To see that whole idea come to fruition.

WILSON: Yes. I think I was really blessed to be able to be part of that. A lot of people get to see those things from a part of that life cycle, but it's rare to be able to see it all the way through like that. So for me it's very personally fulfilling. Very very proud of the team we got to do that.

JOHNSON: You mentioned some of the vendors and some of the delays because they were learning, also, the processes. I know they did have issues finding vendors, because so many people that had built spacecraft before had retired or had left and gone on to other things, since it had been so long. There was an effort to get those vendors up to speed, and able to do what they were going to do, and then to get them to you, and then as you mentioned the processes. Do you have any memories of any of those type of issues?

WILSON: Absolutely. One was a timing issue and one was just like you mentioned; the fact that a lot of those vendors who built space parts, the last big spacecraft we built, human-rated spacecraft, was Shuttle. Others continued to build satellites, both for commercial and DoD [Department of Defense]. There was a little bit of that capability. But the thing we were building, Orion, was so much bigger and so much more complex than any of those systems that had really been built in 40 or 50 years that the machining base out there for a lot of the mechanical parts was very small.

We also were right at the trough of the recession too. Two things were happening in the vendor base. One was lots of companies had gone out of business and weren't available, so the

available vendors were smaller. Then the ones that remained were very very hungry for work. We had two things happening. One was we had vendors that were bidding on work that maybe didn't fully understand the complexity of it. Then of course since the amount of vendors was small, they won those contracts, and then it turned out it was a challenge to help get them up to speed. Then we had other vendors that really were pretty good at it, but they were so starved for work, they bid on everything. Then, because again, the vendor base was small, they won a lot of it, and they actually ended up over their capacity.

Both those things were challenges for us, so we actually used many NASA folks, machining experts and different things, to go back and be out in the field with those vendors, trying to help them learn to build those parts and really gain that capability back. I think overall it's been very good because I think as a country our ability to machine complex parts is really way beyond where it was back then. Of course it's not just us now, but we were one of the first doing it. Now you've got companies like the commercial company SpaceX and others doing some of that. Of course SLS too. A lot of the early folks, we were the first to work with them. It really helped some of those other programs in some ways.

I talked about how we tried to improve. Early in that first phase of EFT we were part-starved for a lot of those reasons. We were trying to build a vehicle without all the parts or maybe they were coming in in the wrong sequence. We did a lot of that work with the vendors, which helped. One of the other things we did within the program is we learned how critical supply chain management was. We formed what we call a Demand Management Group that actually tracks the supply chain and works day to day with those vendors. They work very closely with us. They're actually part of production operations for us, but they also work close with our assembly folks, and we've made lots of improvements on things.

I mentioned earlier that pressure vessel, we've gone from 30 some parts to 7. That's helped us from the assembly side. But again, that pushes hard on the industry supplier side because now those 7 parts are much more complex to manufacture than the individual 32 parts. It's always a balance what you do, but we continue to push the supply chain, push the vendor capabilities, and really try to help them to produce parts and produce more efficiently for us. I think we've gotten to a good place now in EM-1 where those vendors are doing very well for us.

We always have late parts. We always probably will. I've done a lot of benchmarking with other companies and other programs outside of NASA. I went to visit Joint Strike Fighter. We went and talked with them and their supply chain guys, and I expected them to tell me how they'd solved all the supply chain problems, because they'd been around for quite a while. It was a shock to learn that they've got very similar problems to the level we have today. I think we're really pushing the industry but we're learning a lot, improving a lot.

JOHNSON: Why don't we talk about the launch of EFT-1 and that experience. I'm sure you were there to see it. Just what it felt like. You mentioned seeing it come out and roll out and how you felt about that, but talk about the experience of the launch itself.

WILSON: There's a couple things. I talked the rollout one when we first rolled out of the building and the question we got. The second thing that's there was as we rolled that out I was up by the VAB [Vehicle Assembly Building]. It was nighttime and all the lights were on and we were transporting the vehicle stacked up from the O&C Building out to the launch pad, and it passed in front of the VAB. I remember being there and waiting for it to come and turn around

the corner. After having spent pretty much every day for several years around this hardware, you know it's big, but you just don't quite realize it.

When it turned the corner by the OSB [Operations Support] Building at KSC near the VAB—the OSB is a six-story building—and when it turned the corner it was nearly as tall-looking as the OSB, and some of it was perspective, and some of it is that it's just a big vehicle. That was a personal moment where you realized just how immense this thing is that we've built and how much bigger it is than Apollo. That was one of the experiences leading up to launch.

Another one leading up to it was we had the good fortune of having several of the Apollo astronauts here for the renaming ceremony of the O&C to the Neil Armstrong Operations and Checkout Building, and had the opportunity to go take them through and show them Orion before we had rolled out. Hearing them look at it and kidding each other about, "Holy cow, Buzz [Aldrin], what would we have done with all that space," you realized just how much bigger we are and what we're doing. Seeing some of the pride those guys took in what we were doing to follow up on the great things they did was personally fulfilling.

But nothing beats a launch day. Of course the first day we didn't go. It's early morning, you've been out there for quite a while watching. I was in a unique position. I had the opportunity, being the production guy, most of my work is done by the time we get to the launch pad. I had the opportunity to either be in the [Launch] Control Room for it or to be outside. It was an easy one for me. I wanted to be outside and see it.

Sitting there and watching the sun come up and going through what you feel when you scrub a launch the first day was hard. Got up for the next attempt, got out there. Getting down into final count. The anticipation you got is amazing and incredible on its own.

I'd forgotten when a Delta IV goes up the big flame plume comes up around the vehicle before it actually lifts off. When we got to t-zero I was extremely excited. Within the first second or two you see a giant flame engulf the whole vehicle. You get the sinking feeling. Then suddenly you see Orion poke up through the top of it and of course the launch vehicle following going up. Unfortunately I don't have the words to describe it. It was just a very very good feeling, a feeling of accomplishment and a feeling of great pride for what the team had done and what our country was getting ready to start doing again.

Then I quickly ran inside to try to get to some monitors and some TV things to see the rest of the mission. I know it's not possible to hold your breath for four and a half hours but I'm pretty sure most of us did until we saw those first parachutes open up as we came back down. Once we saw main parachutes I think I finally took a breath and got to just really appreciate what had been accomplished.

JOHNSON: The attention to NASA by the public of course has waxed and waned over the years. I know down here we would get comments from people out in the public that thought that JSC was closed after the Shuttle was ended. I was wondering at KSC in Florida building up to this launch and then the actual launch itself, do you feel like the public was engaged again?

WILSON: It's funny because I got a lot of those same comments. You'd be on an airplane someplace, and somebody'd see something on your computer or your bag, a NASA thing, and ask you what you're doing now that you're unemployed. I got the same thing from family. I grew up in northern New York. Once you're away from I guess I'd call it the bubble that's around each of the NASA Centers or the main contractors where everybody knows what you do,

once you get outside of it, people really thought—it's funny. The Constellation cancelation was really picked up by a lot of people. I was surprised how many people knew about that, and just assumed between that and the Shuttle retirement that we were closed.

That was hard to see. At the same time I think watching the EFT launch and going home afterwards and watching the news, and just trying to get home many hours after launch and after the mission, trying to get home. The amount of cars still on the causeway and the amount of traffic feeding back trying to get back to Orlando and back to I-95, that was a good feeling that at least locally there was still a huge amount of support. Of course as you start to see the news reports come in from around the world on it, you realize that it's a little bigger than locally.

You still for a while would still get comments when I'd go back home, or get outside of that bubble, but I don't see that as much anymore. I had the opportunity a couple months ago to go—it was again in the upstate New York area—I went and visited several schools. One of those schools was a middle school, and kids had to sign up to actually go and see our presentation on Orion. I was expecting probably maybe 20 or 30 kids and planned to talk for about 30 minutes. I walked in and it was over 500 kids. After my 30 minutes, and I planned about 20 minutes to show them some pictures and talk about it and then answer questions, they had so many questions and were so excited about it, I spent almost two hours there answering questions. I finally had to leave questions unanswered because we just couldn't stay anymore.

There were kids, they couldn't keep their butts in their seat trying to raise both hands asking questions. Just how excited about space, and how much they knew about it, that was encouraging too. I think we've turned a corner. I haven't been asked what I'm doing in my retirement for a long time. It's been probably a couple years now. I think people really do know more than I think sometimes we give them credit for now.

JOHNSON: I think there's always going to be people out there that are interested in what space does, and especially kids. You just have to capture that energy and that excitement. If you want, we can stop for today, so we don't go too long.

I appreciate you talking with us today, and I really appreciate you cooperating and doing this with us. It's going to help a lot.

WILSON: I'm very thankful that you guys are doing this and again as a kid growing up I was always fascinated by space stuff and reading I guess what now are history books. That's how the next group of kids is going to learn stuff, through things you guys are doing. Thank you.

JOHNSON: All right. We'll talk to you soon. Thank you.

WILSON: Okay, take care.

[End of interview]