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

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INTERVIEWED BY JENNIFER ROSS-NAZZAL
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ROSS-NAZZAL: Today is July 8th, 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 in Florida. The interviewer is Jennifer Ross-Nazzal.

Thanks again for taking some time out of your very busy schedule to talk with us. Certainly appreciate it. I read through your transcript, and last time you talked about the launch of EFT-1 [Exploration Flight Test 1] and your feelings on seeing the culmination of all those years of hard work. I wonder if you'd talk about the landing and the problems with the uprighting system.

WILSON: Yes, good question. When you launch something like that and you build something for the first time you're really worried. You know you've done everything you can to try to do it right, but you're not sure. You're always worried about the thing you might have forgot or something that you might have thought you designed well that didn't work.

I think I mentioned before I don't think it's possible to hold your breath for four hours, but I think a lot of us felt like we did until we saw the big parachutes come out and begin to settle down over the water. It was a great feeling to see that. Of course when we settled into the water and landed, we had some of the uprighting bags that didn't fully inflate or a couple that did inflate and then deflated. We'd had some problems with the systems that pressurize those early

in the production flow, and we'd worked through those changes, so we were pretty confident we got it right, but I wasn't sure when we saw that.

Two things went through my mind probably. One was thinking back to the earlier problems we had and trying to figure out did we not do something right. As it turned out, the problems we ended up seeing there during landing were a different cause than the earlier problems we saw. I think we did do our fix right, but we clearly had some more design things to work on to improve it for EM-1 [Exploration Mission 1].

The second thing that went through my mind is holy cow, if we just got through throwing something 3,000 miles into space and around the planet and sending it back through the fires of reentry and landed, and all we had a problem with was a couple uprighting bags not fully inflating, that's pretty amazing for a first flight too. While it was an issue and one we've corrected since for EM-1, to me the fact that that was the only problem we really had in that mission was outstanding for the first time we've built a human-rated spacecraft in half a century basically.

ROSS-NAZZAL: Were there any other lessons learned though from EFT-1 that will be applied to EM-1?

WILSON: Yes. I think there's quite a few. That was the whole purpose for trying to do that test flight. We've spent a lot of time talking about whether doing a test flight ahead of the SLS [Space Launch System] rocket made sense or not. Of course we decided that it did. Getting that early data from EFT-1 has really helped us with EM-1 planning. Not even sure where to start, there's so many. A lot of the things we learned from the instrumentation on the vehicle, from the

stresses and loads that it saw during flight, helped us to reduce quite a bit of weight. For instance we've got 400, 500 pounds out of just some of the metallic components of the pressure vessel alone since EFT based on some of that data.

The heat shield was something we learned about. It's an ablative heat shield. In EFT we had what we called a monolithic heat shield. It was a five-meter-diameter heat shield that had a piece of honeycomb over the top of it with individual cells all filled with Avcoat, which is the ablator that we use. During some of our early testing what we saw was because it's one big giant piece, five meters in diameter, as things heat and cool in the structure we were seeing some cracking of the Avcoat that we had to do repairs on prior to the mission.

We did those repairs, we flew the mission, and we were happy to see that the repairs worked successfully, but it really led us into thinking about whether we want to change the design for EM-1. Of course what we have now, rather than that big monolithic five-meter-diameter block of Avcoat, are smaller blocks of Avcoat that we bond to the heat shield for EM-1. We do that very similar to the way you do tiles on backshells, or the way [Space] Shuttle did tiles. These blocks will help us really address that cracking and stress issues we had with temperatures. That was a big thing we learned.

Of course the CMUS [Crew Module Uprighting] System we redesigned. We found where there's some chafing as those bags deploy and have redesigned that system as well. Those are some of the things I can think of off the top of my head. Big mass reductions based on the data, and heat shield was probably a big one.

ROSS-NAZZAL: You said something that I thought was interesting. You decided that it was a good idea to move forward with the test flight before the SLS was ready. Can you talk about some of the pros and cons that were being tossed out for both sides?

WILSON: Yes. I think any time you decide to fly something and build a vehicle there's costs associated with it. Of course there's resource demands too. Some of the negatives were the cost of inserting that flight in there before SLS took away from some of the budget we might have had available to do development on the EM-1 vehicle itself. Of course when you have resources and people working designs for EFT they're not necessarily working all the follow-on vehicle stuff. Those were the downsides.

What we decided is if we could make EFT as close to what we thought EM-1 was going to be at the time, with the exception being those systems that you need for a crewed vehicle or unique to SLS, then we could still learn a lot, and we could also use that data to help us with EM-1 design going forward. If we could balance that, then it would be a good idea.

Of course you do the test flights to learn things. We knew we'd learn stuff. We weren't exactly sure what you'd learn, but that's the nature of test flight. So, for all those reasons we felt it was important to do that and get the early data and then feed that into the design so that we had a better vehicle and a more mature vehicle when we did put it on SLS. Of course that was the approach we took, and in hindsight it turned out to be a good approach. I think some of the things I previously mentioned were big lessons learned that we got from it. It's really helped us to mature the vehicle that we're building today.

ROSS-NAZZAL: How did you guys capture those lessons learned and then disseminate those throughout the program?

WILSON: Another good question. I can talk specifically in the production area, which is my area. We actually started a lessons learned capture while we were still building EFT. We figured with the folks working on it, it was the best time to understand things. We learned about what we planned to do versus how reality really worked out was while we were doing it and it was fresh in our mind.

In production we actually started that process about halfway through the EFT-1 build. We had a person we assigned here to go basically work with everybody from the technicians to the CPEs [Certified Project Engineers] to the engineering team and really capture the things as they occurred or shortly afterwards. We continued that process all the way up through the mission and through recovery and then of course getting the vehicle back here and doing disassembly work.

We actually went and captured that in a document. We did several hundred interviews with technicians and engineers and manufacturing engineers, captured the themes out of that, and then put them into a lessons learned document. We were very adamant about making sure that document wasn't just some volume of data that goes on a shelf somewhere that doesn't get looked at. We actually used that when we went back through the Orion CDR [Critical Design Review]. We used those things we learned as criteria to evaluate the design that we had matured for EM-1 and EM-2 as we looked through CDR. We really made sure a lot of those lessons learned were actually captured, and designs were updated, or processes were updated to take advantage of those.

I'm really happy to say—I don't remember the exact number—but nearly all of those have been captured. Probably a simple example to understand this is the heat shield installation, for instance. We had several hundred fasteners with very tight tolerances to be able to put a heat shield on the vehicle in the original EFT design. It was extremely challenging for the team to try to figure out how to take this very eloquent design solution but actually manufacture it and build the vehicle that way.

As a result, in EM-1 now we only have a handful, I think it's 20 to 30 fasteners with much less tight tolerances on it. It's a very easy way to assemble that now. That's one simple example to get your arms around about how we've improved, how those lessons learned fed in.

ROSS-NAZZAL: That's quite an effort. How many people were working on capturing those lessons learned?

WILSON: Like most things in Orion, we don't have a lot of folks to do that. We really had one lead for it. Then of course lots of folks provided fractions of their time to provide the data that went into that study. Really just one person leading it. Again this is the production part of it. There were other efforts in the other CAMs, but just one lead and a lot of slices of technicians' time and engineers' time to go feed that process.

ROSS-NAZZAL: Did everyone sit down and do an interview or were they just asked maybe to type up a memo and share their lessons learned?

WILSON: No. I think not everybody in the program went and did it, but what we did is we tried to make sure we interviewed all the key folks who had a role in the build. There was a very specific effort to go down, talk to the technicians on the floor, and solicit those inputs. Then almost everybody who had a comment or had some thoughts for lessons learned was interviewed in it. Again I can't remember the exact number of folks but there were many. They ranged from technicians working on something like the heat shield installation or those fasteners, all the way to manufacturing engineers who were trying to put the processes together, to the design engineers who were designing the heat shield for instance.

ROSS-NAZZAL: How many total people work in production?

WILSON: On the NASA side of it, on the nonprime side, we have between 24 and 30, depending on the time phasing. On the contractor side between Lockheed and ASRC [(Arctic Slope Regional Corporation) Federal], who's Lockheed's support for technician labor, there's about 250 or so.

ROSS-NAZZAL: That's not a very big labor force, when you think about it.

WILSON: No, it's not, but we've learned a lot I think as we've gone forward. One of the things we looked at early on when we set up the factory and decided how to staff was the Shuttle workforce and what little data we had on the Apollo workforce. Shuttle was fresh in everybody's mind. It was good and bad. Shuttle employed a lot more people, but as it ramped

down a lot of those people were looking for future work, and so we were able to pick up a lot of the best of the best from Shuttle.

What we did in Orion is we tried to design—we learned a lot since Shuttle—we tried to design a vehicle that took less people to assemble. For good or bad, we've got a much smaller team, but it's a much more efficient team with an easier vehicle I think to assemble now. It has different capabilities than Shuttle, but we've tried to design it smartly to take less people to process and build.

ROSS-NAZZAL: Along those same lines I've read that the capsule is supposed to be reusable. That was how Shuttle was sold. Reusability was going to cut cost and we would be able to fly into space much more cheaply. Can you talk about that reusability and the vehicle itself here and some of those challenges it poses and if that's been able to help you cut cost in any way?

WILSON: It's a great question, one we get a lot. We started off with this—I think at the time we didn't know it, but it was a relatively simple question. Should it be reusable or should it be disposable? What made more sense?

As we looked into it, it's not really as simple as we thought it was. It's really an incremental approach we took to it. We looked at it from a cost perspective. Some things make a lot of sense to reuse, and some things make a lot of sense to just buy a new piece or build a new piece for it. We ended up actually coming up with a mixed mode for reusability where some things may take you so much effort to disassemble the vehicle, get the part out, recertify it that it costs you too much, where the new part might be half the cost. Or there's other places where the

equipment is such high value, like avionics for instance, that it makes more sense to reuse it because the labor cost to take it out and recertify it is much lower than to rebuild.

The model we actually have right now where we don't use for instance the primary structure currently because the labor we believe is going to take more labor cost to recertify that, but we do use all the avionics boxes for instance. Now we are trying to use the data from both EFT and EM-1 and EM-2 to be able to also certify the structure for reuse ultimately too.

I think in the end what you'll see is it won't be completely reusable, it won't be completely disposable, it'll be the right mix for the cost.

ROSS-NAZZAL: I thought it was fascinating how there have been so many studies done talking about Shuttle, and how it was sold this way, but it ended up of course not being as efficient as people said it was going to be. I just thought that was curious. I wondered what the thinking was behind that.

WILSON: That was exactly what we went into. I think coming out of Apollo, which was mostly disposable, after a mission we'd send it to museums. I think people at the time said, "Hey, we got to figure out how not to do that. Let's make it reusable."

The preliminary look at Shuttle said, "Yes, that makes a lot of sense, it'll be more like an aircraft." But of course as you get into the space environment, things are a lot less forgiving, and it ended up driving a lot more inspection and disassembly. Those labor costs quickly grew also.

We were fortunate in our timing of having data on the Apollo method and on the reusable method from Shuttle and being able to try to find the right balance to thread the needle between the two.

ROSS-NAZZAL: I wonder if you could talk about NASA's international partners and the agreement that led to that partnership for the Service Module.

WILSON: Another great question. In the original plans we had back in Constellation and even in early MPCV [Multi-Purpose Crew Vehicle] we were building a fully U.S. vehicle. Then over time as we looked at the [International] Space Station [ISS] model and the benefits that international partners brought to the table in Space Station, we began to think about whether that made some sense for us on Orion as well.

We got into some discussions with ESA, the European Space Agency, on it. I think most people recall—or maybe they don't—back in Station the way we trade services between countries is in terms of barter. We don't actually exchange money between the countries, we exchange services. Those services have a value. We keep a balance sheet for how much value each partner is bringing to the table and which country owes which country services in return.

Coming out of Station and the Shuttle flights we were providing, there was some services essentially on the debit sheet that the Europeans owed the U.S., and so we started talking about ways that maybe that made sense to bring on an international partner. We of course did partner with ESA, and ESA brought in their prime contractor, Airbus, to support it. Today we have them as a full partner to provide a major chunk of the Service Module, a piece that we call the ESM, or European Service Module. It's primarily based on their experience with in-space propulsion, so it has the main part of the Service Module which includes all the tanks and propulsion systems and solar arrays.

EM-1 will be our first vehicle where we actually use the European Service Module. We're already working with that team at Plum Brook Station [Sandusky, Ohio] now to do testing of their structural test article. They have basically a mockup of that Service Module that we're putting through environmental tests. It's been a good model not only for the technical side of the vehicle testing we do but also for how we have this international team work together, and the processes that we put in place, and the way the people work together.

Very shortly in the early 2017 timeframe, we'll have the European Service Module arrive here at Kennedy, and we'll begin to integrate that with the rest of the vehicle. It's an exciting time to go from the stand-alone Constellation model, as we've matured into a different U.S. model, and then now an international team. It's exciting and I think it's got a lot of opportunity for all of us.

ROSS-NAZZAL: Were there any changes that needed to be made to the Orion vehicle as a result of choosing a different provider for that Service Module?

WILSON: There were some. I think probably the biggest changes were when you try to define the interfaces between something, when it's completely U.S.-built all by the same manufacturer you can be more integrated between the pieces if that makes sense. When I talk about the pieces, the Service Module itself has this central piece that we now call the European Service Module. It has an upper piece that integrates with the Crew Module called the CMA or Crew Module Adapter, and it has fairings and a spacecraft adapter that integrates to the rocket.

What we ended up having to do as we tried to carve out this European piece of it, we tried to simplify those interfaces and put them in the right places so we could do a little more

stand-alone work in the U.S., a little more stand-alone work in Europe. The simpler that interface was, the easier that partnership would be from a technical perspective. In doing that, we made some changes to the CMA and to the spacecraft adapter at the lower end to be able to integrate the two together. I think that's probably the main things we did with it.

ROSS-NAZZAL: Have you seen any challenges or issues working with ESA?

WILSON: I think any time you bring in a new partner there's challenges in how you work together. I think that's the biggest part of it. I think EFT was a great pathfinder, I think I mentioned earlier, for us in terms of how you build a vehicle. We had a lot of things we had to learn just in terms of how you receive parts, how you put things together. Things we learned like I mentioned with the heat shield and how you produce those.

We had a lot of time to use EFT as not just a pathfinder for the spacecraft itself but for the processes and the teams and the people. We got through that. Now with the Europeans that's one new aspect to the team that we're bringing in. I think there'll always be challenges when you bring in a new team. They're not unique to international partners, I don't think. I think it's just as you bring in a new group of people, a new supplier for such a large part of the spacecraft, there's challenges in just how do we work together and how do we plan all that stuff.

But just like EFT, I think by the time we get through the early parts of EM-1 we'll have figured that out. I think it'll be very smooth for us. There are the obvious challenges when you're working with a partner who's in a different country or that far away, working remotely: how you share data back and forth, how the teams work together; the different approaches that

different countries or different contractors in different countries, the way they approach problems and their processes trying to integrate between the two.

Then of course there's the export control law in International Traffic in Arms [Regulations] or ITAR law that we have here in the U.S. that limits what we can and can't export or talk about with foreign nationals too. We've had to do a lot of work with the [U.S.] State Department and export control to be able to work through the right things and transfer information in the right way. That tends to slow us down some, but of course those laws are there for a reason, to protect U.S. interests as well. Those are probably the biggest challenges.

ROSS-NAZZAL: ISS has a number of partners. Do you see Orion expanding and including more international partners since this is an effort really to explore deep space and we might bring on say the Russians or the Chinese at some point, if we're allowed to work with them? Do you see that being a possibility?

WILSON: It's a great question. I think you have to think about Orion in the bigger context of exploration. Exploration is going to take a lot of assets both in space and on the ground to be able to really explore places we want to go and for the missions we eventually—when I say we now, we humans—want to go to. I'm not sure more partners specifically for Orion, but I certainly see opportunities as we go forward to do exploration. There's other aspects of things we'll need. We'll need landers. We'll need in-space propulsion systems. We'll need habitats and relay systems. I think all those provide places for the international community to participate as well in the larger mission.

If I could use my crystal ball to look forward, I'd be very surprised if 50 years from now we didn't have much more of an international presence there, working together and sharing resources. When you do these things it's a big challenge for one country to do it alone. Doing it together I think we accomplish quite a bit more as humans than we could trying to do it individually.

ROSS-NAZZAL: If you could, looking back over your time with Orion. What do you think was your most significant challenge during your years there?

WILSON: I got to pick just one, huh?

ROSS-NAZZAL: You can identify several if there are several.

WILSON: I'm just joking. I think for me personally, well, any time you design something new there's a huge host of challenges of how you design things and your trades and how you balance cost, schedule, and budgets from a programmatic perspective. There's all those things at a big global program level. Specific to the production area that I've led up here, I think the biggest challenge was also our biggest plus also.

We had a clean sheet of paper to design the factory and the processes and to figure out how you build spacecraft. It's both a blessing and a curse. We didn't really have a blueprint to just pick up and start following. We had to create it, which was hard, but by us getting to create it, we were able to make it as efficient as we could make it for ourselves. I think that was the biggest challenge.

The way that manifested itself, early on it was how do you build the factories, what do the factories look like, where are they. Of course we gravitated our primary big manufacturing in New Orleans [Louisiana] at MAF [Michoud Assembly Facility] and assembly operations and test at Kennedy. Then of course where do we do large-scale environmental tests? We've gravitated to Plum Brook Station for that. But, all those things originally weren't really defined for us, and so we had to figure that out and try to make the best balance for what made sense technically but of course what fit cost and schedule constraints as well.

Early on, once we picked the locations, it was a lot of building work, facility type work to build those factories and build the test capabilities. The O&C [Operations and Checkout Building] was a building built in the '60s for Apollo, hadn't really had significant mods [modifications] done to it since then. It did support Space Station and Shuttle, but from a large-scale perspective it needed a significant amount of work to bring it back up to where you could process today's type of spacecraft.

We put quite a bit of time and many years into building that and making it the right facility, doing a lot of benchmarking with other companies and other factories around the world to see what kind of features we should build in.

Of course similar type things happened at the portions of MAF that we use for Orion. At Plum Brook we had to go figure out how to build test facilities all in a single place to be able to test large-scale spacecraft like Orion, but also we sized that for lunar landers, or at the time in Constellation what were landers of any kind, which was really our driving case for how big things are.

When you look at a place like Plum Brook, we had to do things that nobody's really done in the world before. We had to build a vibration table that was large enough to shake a lunar

lander at the huge size and mass that that takes. We had to build an acoustic test facility there that, when you looked at size and volume of sound, was about eight times greater than anybody in the world had ever produced.

Any time you're doing things that are first time biggest in the world kind of things, there's tremendous challenges to do it, and to do it in a way that made sense from programmatic, cost, schedule, and risk-benefit too. Those were our early challenges.

When we got through all that, I think we thought we were all set, probably a little naively. Then we started building our first vehicles. Of course we had lots of challenges there of how do you do that. What kind of processes do you need? Where do we get our workforce? How do we train them? All those kind of things that went into it.

I think EFT as I mentioned earlier was a big driver in helping us wring that out. I think that brings us to today where we're building EM-1. I think we've wrung out a lot of the facility things that we had early on. We've wrung out how do you build the vehicles. I think now what we're trying to bring into is how do you build full-scale Service Modules, and do that in partnership with our European partners.

Then of course how do we begin to move from the test flight regime of EFT, EM-1 into our crewed phase in EM-2? I think our big challenges beyond there will be okay, now we've learned, we've gone through the development, we've fielded a system that we know works. How do we move into more of a steady-state production phase to produce those vehicles and to produce them at a cost that's feasible for the Agency? That's a really really long-winded answer.

ROSS-NAZZAL: It's very detailed, we appreciate those kind of details. Conversely, what do you think is your most significant contribution to EFT-1?

WILSON: I got to think it's very similar to what I probably just described. I was in a really unique place I think when we first started talking about exploration. I think I mentioned earlier in the interviews previously I was at [NASA] Headquarters [Washington, DC] when we started to figure out the early requirements for it. I think the work we did there and the early trade studies we did that set the requirement set for what Orion needs to do was a big part of it.

We may not have realized it at the time, but what we set was requirements for a vehicle that's really got a lot of capability. As missions have changed and evolved over time, as the program has changed through early exploration to Constellation to where we are today, the capabilities of the vehicle that we defined in those early requirements still provide the vehicle that can meet all those mission parameters. I think that was one thing to me that was very important. I think that was probably the contribution that I think helped us get to where we are today.

Of course the other one is from a production standpoint. Starting with a clean sheet of paper and trying to make all the decisions we have, to try to put in place all the infrastructure and the ability to build and manufacture vehicles has been a big part. I'm pretty proud of both of those. When I say proud, as you know, it's a team of folks. We've got an outstanding team of people that's really pulled through to do all that work. It's really rewarding to see it where it is today, going back to when we were looking at pieces of paper and trying to write shall statements for what the thing should do.

ROSS-NAZZAL: Could you identify some of those folks who've made significant contributions that you haven't talked about or maybe who you'd like to mention?

WILSON: Yes. I think there was a requirements team we had at Headquarters. I'll probably have to dust off, because I don't want to forget folks. But we started early under Admiral [Craig E.] Steidle and there was a team from across the country in different Centers participating in that. I know we had folks like Scott [D.] Altman and Brent [W.] Jett out of the Flight Crew Office. We had Mike [Michael F.] Lembeck was assigned at Headquarters at the time helping oversee some of those requirements efforts as our direct supervisor under Admiral Steidle.

I'm trying to remember. Bret [G.] Drake, Jim Gefery, and Terry [O.] Tri were up there out of JSC. Ed [Edward J.] Stanton was out of [NASA] Ames [Research Center, Moffett Field, California] at the time. Warren [I.] Wiley was out of KSC. Wayne [L.] Peterson from JSC. Those are some of the folks off the top of my head. Don [Donald E.] Shick was out of Langley I believe it was. It was a relatively small team working requirements early on.

Then of course when we started up production here, I started as the JSC person to lead production, but we formed the team out of Kennedy early on to help us with a lot of those facility activities. Glenn [C.] Chin was brought on as my Deputy at the time and Glenn still remains here in that position, has done a great job. I'm trying to think. Mike [Michael J.] See out of Johnson was in the original T&V group, the Test and Verification group, but eventually came into production as well and helped us quite a bit with our test capabilities. And Rafael Garcia as well.

Ed Stanton, who I mentioned from Headquarters, actually ended up moving from Ames. I think he went to JSC and then to Kennedy, and we brought him in on the team here as well. So it's quite a few people.

ROSS-NAZZAL: You've got quite a lot of people who made significant contributions.

WILSON: I forget if I said it before too, but I've talked about the team that we've got that have helped support it. I think early on Skip [Caris A.] Hatfield I think did a nice job forming up the program for us really and getting us going, and then played a very significant role in the startup of all that and was actually who had hired me in at the time.

Eventually Mark [S.] Geyer took over and I think Mark as the NASA Orion Program Manager and Cleon Lacefield, who was the Lockheed Program Manager at the time, they served a very critical role—they were at the helm when we went through the transition from Constellation to where we are now. I think the fact that Orion came through that in the way that we did was a huge testament to Mark and Cleon's leadership in that timeframe. It was a time of extreme turmoil I think for all of us in the program as we talked about before. They did a couple things that I think were really significant that allowed us to move forward.

One of the things Mark was adamant about was we are still required by law to spend money wisely and to do the best we can in this program even while we're being canceled. He drove that hard with the team to do the best we could and really set a steady path for us so that we could put our heads down and concentrate on getting there and doing good work. I think that helped the team tremendously. It also helped us produce some very valuable things like the pad abort test and of course the early parts of EFT.

I think Mark and Cleon both also helped a lot in trying to show our stakeholders the versatility of the Orion design, of what we were building, and how it applied to this new thing called MPCV. I think they both did that in the way that they could from both the government and contractor perspective that really helped us come through the other side and helped our

stakeholders understand the value in what we were doing. I think those are two folks I'd give a tremendous amount of credit to for where we are today.

ROSS-NAZZAL: Along those same lines Mark Geyer has said that the Orion Program has learned to persevere. Would you agree with that statement?

WILSON: Yes, I absolutely would. Trying to think of how to put it. There's so many ways that that's true. On the surface you could say we've learned to persevere going through Constellation and then eventually the turmoil that brought us to MPCV and where we are today. That's the top story. But I think the way we did that is through many many changes at the lower levels.

When Constellation was canceled it really forced us to evaluate how we do things and all of our processes. We've learned to be very adaptive and really question the processes we have. Are we doing this process blindly because we've always done it? Or are we doing it because it really provides value to what we're doing? By thinking of things that way we've really become much much more efficient than I think we were in the early days. That's part of this "trying to persevere." When you have tough times you can either fold up your hands and walk away and say, "We can't do it," or you can try to adapt and do the best you can to do great things with what you've got. It's something Mark really set the tone for, and it's something that I think has become part of the culture of Orion.

ROSS-NAZZAL: Can you give an example of one of those processes that you looked at and thought well, yes, we've always done things this way, but if this is too costly or it's not going to

work with the schedule, and how you applied some of those lessons learned and made a change and it's worked out to become much more efficient and just as effective as in the past?

WILSON: I'll give a little bit of a global answer to it and see if this helps. A lot of times, maybe early on, we relied a lot on Shuttle processes for instance. Shuttle had a board and then they had a preboard that would help make decisions and they had these other working groups underneath. Sometimes there's some decisions you need to go through that kind of process for. We were probably using that early on for many of our decisions.

Then later on as we began to question that, what we tried to do is change from the model where all the decisions go through this very rigorous board structure to what things should go through it, and what levels should other decisions be made at. There was a big effort where we tried to push decision making to the lowest level that made sense but also to make sure we had checks and balances on that and to make sure that we had what we called reclama paths if somebody disagrees there.

That's a very simple process example, but when you go through the amount of decisions that are made just on a daily basis within a program that saves quite a bit of people's time and it still allows a decision to be made. You could argue a lot of cases it's made better because it's made by the smart technical folks where it made sense and where it doesn't make sense those things would be rolled up. Really pushing that decision making to the lowest level with checks and balances and a reclama path has allowed us to do a lot more with a lot less people and resources. That's one example.

ROSS-NAZZAL: Well, I think we've exhausted our questions. We've actually come in a little under time. I wondered if there was anything else that perhaps Sandra [Johnson] didn't cover last time or you wanted to talk about today.

WILSON: No, I can't think of anything other than just I know I told Sandra this, but I just very very much appreciate that your office is doing this and taking the interest to do it. As somebody who ever since I was a little kid loved space, and reading the things from the early days of space and wishing there had been more of this kind of stuff written down then that I could have learned from, I think this is going to be great.

Hopefully as you pull all this together from the whole program this will be a wealth of knowledge for people in the future. Learning how we thought, the decisions we made, and some of the decisions we're making today hopefully will be good things people capitalize on. Some of them may be things people look back on and question, "Why did you do that?" Because maybe it doesn't pan out. This will really give that perspective I think to folks and help make people doing what we're doing in the future better at it. Long-winded way of saying thank you.

ROSS-NAZZAL: It's our pleasure. I certainly thank you for taking time today, and I know you guys are busy and don't want to eat up all of your day. Thank you very much for sitting down with us and sharing your experiences, anecdotes, and lessons learned. We sure appreciate it.

WILSON: Great, well, thanks again, and have a great weekend.

[End of interview]