NASA Johnson Space Center Orion Oral History Project
Oral History Transcript

H. Kevin Rivers
Interviewed by Sandra Johnson
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Johnson: Today is August 2nd, 2016. This interview with Kevin Rivers is being conducted for the NASA Johnson Space Center Orion Oral History Project. Mr. Rivers is speaking with us today by telephone from the NASA Langley Research Center in Hampton, Virginia. The interviewer is Sandra Johnson. I want to thank you again for joining us today. I'd like to start by asking you to briefly describe your background and how you first became involved with the Constellation Program and the Orion Program.

Rivers: I started my career at NASA Langley as a researcher investigating high temperature structural concepts for application to entry vehicles and hypersonic vehicles. I spent a number of years performing research in that area and eventually leading research in that area before becoming the head of a research branch in about 2005.

At that time I took over leadership of the Metals and Thermal Structures Branch within our Research Directorate at NASA Langley and served in that capacity for about a year and a half. Then we reorganized our structures and materials product line within the directorate and that branch was abolished and we created several new branches actually, one of which was the Structural Mechanics and Concepts Branch, and I became the head of that branch. That branch did research to support aeronautic missions with new structural solutions as well as exploration activities. I had several people within my branch who were supporting what was at that time emerging as the Constellation Program.

In about January of 2008 I took a detail assignment into our Flight Projects Directorate, where I joined the Ares I-X Project team. I was in the Systems Engineering and Integration Office, and I led the integrated design and analysis team for that office.

The team consisted of technical experts in all of the typical fields, including aerosciences, guidance, navigation, and control, structures, thermal systems, vibroacoustics, and the like. Our responsibility was to develop the vehicle level loads and environments and deliver those to the Integrated Product Teams [IPT] that were developing the first stage, the control system, as well as the upper stage simulator.

I did that job for about one year and then I was asked to transfer into the Flight Projects Directorate permanently and become the head of the Orion Launch Abort System Office. This was in January of 2009 when I took on those responsibilities. I led the development of the Launch Abort System team, or the LAS team, from January of 2009 through December of 2014. During that time period, our team oversaw the development of the LAS, including numerous ground test demonstrations of our propulsion systems as well as the Pad Abort 1 [PA-1] flight test in May of 2010 and the Exploration Flight Test 1 or EFT-1 mission, which flew in December of 2014.

Just to finish my history, after that I became the Deputy Director of our Flight Projects Directorate, where I served for one year before becoming the Deputy Director of the Research Directorate here at Langley, and I’ve been in that capacity since January of this year, so about seven months.

JOHNSON: Let's go back to when you were the Manager of the Launch Abort System Office. Let's talk about some of your initial duties when you took that position. Where in the development of the Launch Abort System were they at that time?

RIVERS: Very good question. Just to explain that office a little further, we shared the responsibility of the Launch Abort System with the [NASA] Marshall Space Flight Center [Huntsville, Alabama]. We were the lead Center, Marshall supported us with propulsion and systems engineering expertise. Our staff were split about evenly between the two Centers. That was coincidental, that was not on purpose. Langley's technical responsibilities obviously were for managing the project as well as leading the structures, the flight dynamics areas, the power, electrical area. We led the systems engineering effort, but part of that staff obviously was at Marshall Space Flight Center, and we also led the flight test component of that project.

When I came on board in January of 2009 the team had already pretty much developed the vehicle concept, and they were well on their way to demonstrating the overall design and the components of the vehicle, including the three solid rocket motors that it employed, the first being a 500,000-pound force abort motor, which was designed and developed by Orbital [ATK], at the time ATK, in Utah. The jettison motor, which was a smaller motor, was developed by Aerojet out of Sacramento, California. Then the attitude control motor, which was probably our most challenging and advanced technology, was a throttled solid rocket motor, so there were eight pintles or valves around the perimeter of the vehicle, and the attitude control motor could actually direct thrust in any direction 360 degrees around to drive the vehicle in a certain direction.

When I took over we had just fired the first demonstration of the full abort motor, and we had done several ground test demonstrations of the jettison motor, and we were in the throes of developing the design for the attitude control motor. At that time things were a little complicated because we were driving towards the early demonstration of our pad abort capability with the PA-1 test. When I took on the job we were targeting November of 2009 as the date of flying that test. If you can imagine, that's only 11 months.

At that time we didn't have full confidence in the ability of the attitude control motor to perform its functions. We put a lot of focus on that subsystem obviously and trying to overcome technical challenges that we had with that motor in order to demonstrate the pad abort flight test.

Our focus was on the early pad abort demonstration. We had locked into the design that we were developing for that, even though the overall Orion vehicle design was advancing past that. I'll just give you an example. The outer mold line of the vehicle as you see it today has a large cowl if you will that sits atop the Crew Module when it flies. The Pad Abort 1 configuration did not have that ogive structure. Actually the Launch Abort System connected directly to the end of the capsule. We were locked into that configuration until we demonstrated the Pad Abort 1 flight test and could move forward.

Simultaneous with our developing that Pad Abort 1 vehicle actual flight structure, part of the team was continuing to mature our design. Somewhere in that timeframe—and unfortunately I'm going to get confused about when things occurred—the Orion Program executed its preliminary design review in the midst of our run-up to the Pad Abort 1 flight test. I can't remember exactly when that was. But I think it was in that fall, that October/November timeframe. That was our focus, overcoming the technical challenges for that motor, and simultaneously developing the preliminary design for the operational vehicle, which as you can imagine led to some long days and a lot of spirited discussions at times.

A lot of activity in 2009 around maturing the attitude control motor. When I started in the role we had an alternate design that we were developing as a just in case measure, which was not a solid rocket motor. It was a liquid attitude control motor. We were carrying that alternate design in case we were not able to succeed in successfully developing the attitude control motor. We did that for a few months.

Then somewhere along in that timeframe in the fall of 2009 I believe we actually fired our first full-scale ground test of the attitude control motor. We had some issues with that motor early on and some of the high temperature ceramic-based materials that we were using, which were enablers for the design. They had failed in some early small-scale tests. That was really the biggest driving issue for us technically. We were doing a lot of work to try and gain confidence in that material system. The material is a carbon/carbon-silicon carbide [C/C-SiC] ceramic matrix composite material and obviously had a lot of our attention.

Simultaneous with that we were having issues with developing the control system for that motor. We had a lot of subcomponents of that control system that were failing in test and obviously causing us some concern. I guess I'm painting a picture for you to understand that the team at that time was focused on developing a preliminary design for the operational system and then for this one very complicated solid rocket motor we had several issues that we were trying to resolve, materials issues, electronic system issues, and the like. Because we didn't have full confidence in it, we also had a smaller team that was actually looking at alternate designs.

When we successfully fired the first full-scale ground test of that motor, we believed that we had confidently resolved our issues with that material to a point that we could go fly the pad abort flight test. We felt like we had overcome most of the issues with the control system as well. So we made a decision to stop working on the alternate design and focus all of our resources on making the solid rocket concept a reality if you will.

As I told you, we had originally targeted being ready and flying in November of 2009. We ultimately flew in May of 2010. Again the issues and technical challenges that we dealt with the attitude control motor system were what drove that schedule out another six months.

That was where we were in the throes of developing the design in May of 2010 after we flew the Pad Abort 1 flight test. As you know, the Agency made some strategic decisions at the behest of the new [Presidential] administration which had been in place for two years at that point, and the Constellation Program was ended. We were instructed to continue to work through that year and we spent a lot of time planning and replanning. Obviously our energy coalesced around focusing on an early demonstration flight on a Delta IV Heavy, which was the EFT-1 mission that I mentioned.

From May of 2010 or shortly thereafter until sometime in 2011, although our technologists were continuing to mature the design, the project was focused on doing some very interesting things if you will programmatically to simplify the standards and requirements that we flowed to the contractor and the deliverables that we required from them and optimize how we were implementing the project to try and become more affordable. In that timeframe we actually reduced the size of the project oversight team, which we had been using to oversee Lockheed Martin, the prime contractor, and their subs; we reduced that team to about 50 percent of its original size.

We went from about 60 civil servants supported by a similar number of contractors, I don’t remember the number exactly. But our procurements, which primarily funded contractors, were $9 million in 2009. So by the time we got to 2011, our civil service team had contracted to 27 I think, 28, somewhere around there, civil servants. Our procurements we reduced to $3 million. It was about a third of the contractors that were supporting us originally. Maybe 14 or 15 contractors at that point where before we had had about 45 is coming back in my memory.

That's what we spent most of the last half of 2010 doing. Then at that point the Agency had created the Multi-Purpose Crew Vehicle [MPCV] Program. We retained Lockheed Martin as the prime contractor, we pretty much retained the primary design of the original Orion Crew Exploration Vehicle, but obviously the vehicle that we were flying to orbit on changed from the original Ares I vehicle to the SLS [Space Launch System] vehicle as we know it today.

Our emphasis at that point coalesced around primarily developing that early design of the Orion vehicle to fly on top of the Delta IV Heavy. The Pad Abort 1 demonstrated the Launch Abort System primarily, and the EFT-1 was primarily focused on demonstrating the entry capability of the capsule. For EFT-1 our Launch Abort System did not have an active launch abort capability. The only active solid rocket motor that we flew on that mission was the jettison motor so that we could basically get out of the way and let the Crew Module do its thing.

Obviously a lot of our focus from about mid-2011 until we flew in 2014 was on delivering that EFT-1 Launch Abort System. But we were also continuing to mature the operational design. A big focus of that was identifying and driving out the technical risk to the operational Launch Abort System.

Another thing that we did to try and become more affordable was we depended more on the contractor to provide a working system. We minimized our oversight team overseeing the contractor and then redeployed our in-house engineers to actually work alongside the contractor and gain insight into their design by actually participating in the development of the design side by side with the Lockheed engineers. The overall Orion Program directed this change in our operational model and on the Launch Abort System. We obviously embraced it and I like to think excelled in implementing it.

Most of that was because we had forged really strong working relationships with Lockheed Martin through the fires of preparing for and actually performing the pad abort flight test. It was easy to identify areas of high risk where our NASA team could focus to drive down those risks to the operational system and allow Lockheed Martin to spend most of their energy focusing on producing and delivering the EFT-1 flight structure.

Part of that risk reduction was identifying areas in the operational design where we felt there were opportunities to simplify subsystem designs. We focused in on several of those areas. One of them was there's a bumper system if you will between the ogive on the Launch Abort System and the Orion Crew Module. This bumper system, there's like six of them around the perimeter of the vehicle, and they basically absorb the loads and vibrations during launch, preventing those loads from going directly into the Crew Module. Lockheed had developed a preliminary design and our NASA experts were concerned that that design had some issues that needed to be addressed.

They started looking into it. In the process of looking into it, they actually proposed a new design. That original preliminary design, there are six of those units, each one of them weighed about 80 pounds. Our NASA team developed an alternate design which actually only weighed about 16 pounds, so it was a significant reduction in mass. It was a simpler mechanism and so in my opinion less risky technically.

They didn't do this alone, they did it in collaboration with the Lockheed team. There's a lot of design, analysis, and testing to demonstrate its capabilities. Ultimately Lockheed embraced that NASA-developed design and baselined it as their own, and so today the bumpers that they're developing actually are based off of that NASA design.

We did the same thing for the—there's a big hatch on the ogive as well as a hatch inside on the Crew Module, and the mechanisms that keep that hatch closed during flight were derived from the [Space] Shuttle hatch system, which was derived from the Apollo hatch system, so there was a lot of heritage in that design, but it was a mechanized design.

Again our team looked at it and had some concerns about it because the vibroacoustic environment in that area was really high, so the loads were really high. In that situation you really get worried about how much something weighs because if the mass is really high then it's going to drive those loads up even further if you think about it as things sit there and vibrate.

An example is if you're sitting at a red light and a younger driver pulls up beside you and they're enjoying their music, you might notice that your car starts to vibrate. Those vibroacoustic loads can be significant to a design, and that's what we were dealing with. Obviously not because someone was flying beside us playing really good music but more because just the environment is very noisy.

Our guys actually looked at the design that Lockheed had and started focusing on trying to simplify the design and come up with something that would be less expensive to fabricate and also less complicated and lower mass. They actually started exploring a pneumatic latching system which has never flown on a spacecraft before, at least not on an external door. But they had some really good ideas and we spent some time wringing them out, and they came up with this pneumatic system, which turned out to be much lighter and much simpler than the original design.

Lockheed started looking at it and realized that it would be less expensive to fabricate. Also because this was a different way of doing things, we had to bring the community along with us, all of the safety folks and the ground operations folks, the astronauts, because this is a system that they've got to worry about if they have to make an emergency egress from the vehicle.

We brought that whole community along with us and led them through how we had developed the design, all the testing that we had done to gain confidence in it. Ultimately that design was baselined by Lockheed Martin for the production system as well. Those were some areas where we saw risk in the production design and focused some NASA teams on trying to resolve them.

There were other areas. We weren't quite finished with that carbon/carbon-silicon carbide material that we had essentially through careful handling and Band-Aids and all other sorts of tricks made work for the pad abort flight test. We were still concerned with that material and its ability to survive in the actual operational flight environment. Primarily we were not so much that concerned about the material's ability to survive the environment as we were concerned about our ability to predict how it behaves in that environment and gain confidence that we had appropriate margins to the flight loads that it would see in operation.

So we spent a lot of time between 2011 and 2014 working to understand that material. That was a case where we were not necessarily trying to change the design to be more effective or lower cost or less risk, but we were actually just trying to understand what we had and early in the process drive out our uncertainties so that when they start to fly the operational system they'll have full confidence in it.

We didn't do that alone. We did that in concert with the NASA Engineering and Safety Center, the NESC. We brought expertise in from all across the nation to help us on that project.

What we ultimately did in concert with the NESC was we developed and performed a couple of ground tests so that we could demonstrate confidence in the material operating in a relevant environment and empirically demonstrate that we had margin to the predicted loads, which we did in a test. I'm trying to remember when we performed that test. I think it was February of 2014.

That was what the team was focused on. I like to think we did a lot of cutting-edge things through that whole process. Obviously after the EFT-1 mission flew I moved on to other things and turned the reins over to a new manager.

JOHNSON: Let's go back for a little bit and just talk about when Constellation was actually canceled. You were talking about the things that you were working toward, and one of them was Pad Abort 1 that was supposed to fly, but Constellation was canceled in February of 2010. Some of the people we've talked to say that that announcement came as a surprise to them. Did it come as a surprise to your team?

RIVERS: Yes. Absolutely. We had already gotten word or had an impression, I'm not really sure what it was based on, that the launch vehicle, the Ares I and the Ares V, would be canceled. You're resurfacing memories I've buried. But we had every confidence that the Crew Exploration Vehicle, the Orion, would continue. When that decision came down in February we were absolutely shocked. We did not expect that.

JOHNSON: The program was still funded even if it was canceled. It was still funded for another year. The decisions were made to work toward Pad Abort 1 and also EFT-1. That idea started being developed at that point. Talk about working towards that pad abort test with the uncertainty during that time whether Orion was going to continue or not, because you didn't know at that time that the Orion vehicle would actually continue, but you were working toward those tests for that vehicle. Talk about that time and how it was in the area you worked in and the attitude of the people you worked with.

RIVERS: That's a really good question. Obviously we were shocked at the decision. We were instructed, because the program was funded at least through 2010, to complete the Pad Abort 1 flight test. Because there was so much to do in preparation for that test, we really did focus in on that activity, and didn't really think about the overall consequences of having a canceled program very much until after we flew Pad Abort 1 in May.

Although I think it was certainly there in the back of our minds, we had a job to do, and we wanted to do it and do it well. We, the Launch Abort System team, had the luxury if you will of focusing on accomplishing that test. My memories are becoming fresher as I think about this. Obviously the program itself was beginning to talk about the possibility of doing the EFT-1 mission. We're obviously advocating for what we the Agency do next if we're not doing Constellation. There was a lot of that activity going on. We were involved in that, but we were able to focus on our flight test and not think about the uncertainties of the future so much.

The rest of the program didn't necessarily have that luxury. As the decisions came through, the first decision I believe was Constellation ends, Ares I and V are canceled, and the Orion vehicle is canceled, and we'll sort out what to do during this year as you guys wrap things up. I think there was another decision that came out that said no, we're going to actually build the Crew Exploration Vehicle, but we're going to build it as a rescue vehicle for ISS [International Space Station]. I don't remember when that thought came forward.

JOHNSON: I think that was with the MPCV announcement in May 2011. That was the thing that was going to save the Orion at that point.

RIVERS: Wow, that was later than I thought. I'll be honest with you. From the time we completed the PA-1 flight test, we took a breather over the summer. I won't say we took the summer off, that's far from true, but we did take vacations that we hadn't taken in a long time and we did slow down quite a bit and spend a lot more time thinking about the future. I can't remember the timing on all these things, but we did several iterations through the rest of 2010 and then 2011 on the overall program budget. As an IPT lead I was obviously in the midst of all that personally.

JOHNSON: You mentioned the budget and the way that things were arranged. You mentioned the fact that engineers were working alongside the Lockheed engineers, and that helped to simplify some of those systems and to bring in some cost as well as weight savings on some of those designs. I know everyone has budget constraints at different times. But Orion effectively has a flat budget as opposed to Apollo, who had a large balloon budget and then as operating costs level out, and most other programs that NASA has had have had those type of budgets, whereas Orion is completely flat since it started. Talk about maybe working within those types of constraints with the Launch Abort System. I know some of that may have had an effect on the actual pad abort tests that were scheduled and then some of those have been canceled, or it was decided that they weren't needed because you got enough information. How does that relate to the budget and safety?

RIVERS: I obviously was not on the project when the original flight test program was put together. They had already made some key decisions when I joined the team in 2009. Obviously the budget constraints were driving the program to really scrub that flight test program. Originally I think we had three pad abort flight tests in the plan, 1, 2, and 3. We had three ascent abort flight tests, 1, 2, and I think there were three in the original plan. There was an optional high altitude abort flight test that had been kicked around, but I'm not sure that it was ever really part of the plan.

We went from seven abort demonstration flight tests ultimately to two. They eliminated the pad abort flight test, and again I can't remember the timing of when all this happened. But after we flew Pad Abort 1, we had enough confidence in our pad abort capability that we didn't feel we needed to do a repeat of that test with the production design. We originally were going to do the two early flight tests, Pad Abort 1 and Ascent Abort Flight Test 1 [AA-1]. Both of them would have been with the original design of the vehicle because we were moving pretty quickly and we were trying to use the data we were getting from those tests to inform the production design.

Because of these cost constraints we actually canceled that AA-1, Ascent Abort 1, flight test. Then the second and third abort flight tests, we started looking at the flight test objectives for them and it was obviously driven by the budget constraints, but I like to think that we did what was technically right. We looked at those flight test objectives and we made some strategic decisions.

We actually ended up believing that we could optimize one test that would meet both of the flight test requirements and all of the objectives that we had laid out for both of the tests. A lot of that was not just driven by we have less money, we've got to save resources. That definitely influenced us. But also our flight dynamicist and systems folks, they were simulating all of these maneuvers through computational models, and they were learning more about the overall system. The original plan that we had moving to the new plan wasn't really a huge increase in technical risk, based on everything that we were learning as we matured the design.

Before I left the Program in 2013, when we were doing the annual budget planning activity, we realized that this constant level of funding—which is not at all how any development activity works. There's always a buildup of funds as you're beginning to invest more and more into the design and development and then qualification and then things fall off as you get closer to going into production. That's not how Orion is. It's a flat budget.

Essentially a lot of the design things that we're doing have to be planned in and phased over time, which basically just takes you longer to accomplish, but all along that way you're trying to optimize cost and maximize benefit. In 2013 we did a study of the ascent abort flight test, the one combined flight test that we were going to fly, which originally was not just going to demonstrate the abort at transonic speed, but it was also going to do a full demonstration of the Crew Module being jettisoned and then the parachutes opening and the vehicle landing. We made some decisions that was really driven by cost to focus on the abort segment of that maneuver. So the test that they plan to perform now, which I think is going to be in 2019, for the ascent abort demonstration is not going to be a full abort mission. Once we turn the vehicle around and then jettison the Crew Module, the flight test will be terminated and the Crew Module will just fall out of the sky.

JOHNSON: Let's talk about the design of the Orion. People have compared it to Apollo because it's a capsule, but obviously there are technological advancements that go far beyond that or Shuttle or anything else that we've done before. As far as the Launch Abort System, which also looks similar to what was on Apollo, what type of technical advances have been developed for that system?

RIVERS: This is like the Oldsmobile commercial. This is not your father's Oldsmobile. The overall performance capability of the current Launch Abort System for Orion is far beyond what the Apollo system did. Our system actually has the ability of aborting through the full flight spectrum of the Orion vehicle from on the pad under any of the wind conditions that we would expect while we're sitting on the pad all the way up to the point—there's a point when you get up to an altitude of about 300,000 feet where it's no longer—you're in real thin atmosphere. You're not going to abort with the Launch Abort System, you actually turn on the Service Module engines and abort into orbit. Through that full flight regime and that full speed regime, the Launch Abort System can successfully abort.

Apollo actually had several different times in the flight where the Launch Abort System was basically not operational. That's not the right way to say it. They would not have operated the launch escape system because it wasn't capable to successfully abort. I think in general the Launch Abort System for Orion is far superior.

There are a couple of reasons. One of them is we've got much more powerful solid propellants than we had before, so we can produce a lot more thrust, and we can get far enough away to be safe, whereas that wasn't necessarily the case back in the '60s and early '70s. The other thing is the Apollo system during an abort, it did not have an actively controlled system. It actually had a single solid rocket motor about halfway up the system that was perpendicular to the system, pointing out to the side, that would light and basically push that launch escape system away from the trajectory of the launch vehicle whenever the abort was initiated. So that vehicle was passively controlled. The system just came on and it went where it went.

The Launch Abort System that we have today actually because of this attitude control motor that we have, we can actually drive it and steer it as we abort away, which opens up a lot of opportunity to successfully abort.

There are a couple of technologies that are implemented on this design that wouldn't have been possible on Apollo. We've got the reverse thrust abort motor nozzle so the motor actually is firing upwards and all of that hot gas is redirected out the nozzles and it actually turns not quite 360 degrees and points out at an angle. That allows us to have a shorter stack than we would have had on a launch escape system. It's more compact so it's lighter-weight. The abort motor also incorporates a filament-wound composite case, which is the first time that we've used a composite solid rocket motor case on a human spacecraft. The attitude control motor as I mentioned, it's the largest throttled solid rocket motor in existence. Very complicated and very capable, and allows us to steer the vehicle during the abort maneuver.

The jettison motor actually incorporates some new propellant formulations that we've not used before that allow it to burn really clean. The reason that's important is because we don't want to contaminate the star trackers and all of the other components of the Orion capsule whenever we jettison the LAS off. That reduces risk of doing damage in that fashion. There's a lot of technologies.

The ogive structure that surrounds and protects the Crew Module during ascent is a composite structure, you might say derived from the F-22 fighter jet, but again a system that allows lower mass than you might have seen in the Apollo era. A lot of advanced technologies.

JOHNSON: Did you have a chance to see the EFT-1 launch?

RIVERS: Yes, actually, I did.

JOHNSON: Do you want to talk about that or any other memorable moments in your work and in the project working up toward EFT-1?

RIVERS: Let me rewind quickly to Pad Abort 1 in May of 2010. Obviously our fingers were crossed. We were very anxious when that vehicle fired up. But to watch it perfectly execute the pad abort and then reorient—if you imagine it goes up in an arc, pointy end first, and then when it gets to the top of the arc it actually spins around so that the Crew Module is facing forward. Then the jettison motor fires and the Crew Module moves away from the Launch Abort System. Watching that whole thing happen, and then during that test the Crew Module actually landed under parachutes, and the impact of landing was so light, and far lighter than had been predicted. It was so light that all the systems inside remained active, they were I think designed so that they would shut down at the impact of landing on the ground, but it was so gentle that it didn't do that. We overlaid our predictions of the abort flight test, the computer simulations, we overlaid those on the video of the actual abort, and you could hardly tell one from the other, it was amazing. The team did a phenomenal job of predicting the maneuver. That was Pad Abort 1, very exciting.

For us EFT-1, the Launch Abort System was not active, it was just the jettison. What I liked to remind the team of as we were heading into that mission was yes, we have a simple function, get out of the way, but we've got to do it right, because if we don't get out of the way the entire mission will fail. We demonstrated a nominal jettison on a normal launch on that day. There were cameras inside the Crew Module that were looking at the Launch Abort System as it moved away. Obviously launch day, it's early in the morning, and you're out on the causeway and very excited, and watching that Delta IV Heavy launch is quite a moment, quite a memory. It was very exciting to see that.

It was even neater for me. My wife joined me for the launch, and so we were on the causeway. We watched it launch. We watched until we couldn't see anything anymore. Then we went and got in our car with all the other thousands of people that were there and headed off of the Kennedy Space Center [Florida] back to Cocoa Beach where our hotel was. When we got to the hotel we run in and turn the television on and see what's going on. It was just really cool to see that in the time it took us to go about 30 miles the vehicle was well on its way around the world, it almost had completed its first orbit. That whole experience was just amazing and neat.

Obviously we're watching the NASA TV and they're showing the trajectory. We got to see the picture of the Earth from the Orion capsule when it was at its apex on the second orbit, which was I think somewhere around 3,200 miles away, and that was just absolutely amazing and exciting. Then we watched with bated breath like everybody else as the vehicle came back and reentered in the Pacific Ocean. That was just totally cool. I think I spent a couple weeks after that watching and rewatching and looking at everything, all the video that I could find. But the most significant video for me was when we were able to get the data. During the launch maneuver our chief engineer was in the [Launch] Control Room, and we didn't have any way to know real-time how well we had jettisoned. We just knew whether we had done it or not done it. He called me to let me know that they had successfully jettisoned when that maneuver was commanded, which was really cool.

I got to watch that video to see the inside of the ogive of the Launch Abort System as it moved away from the vehicle, which was really really just totally cool. From a personal perspective that's the point where all those pep talks to the team that you guys joined this team to work on a Launch Abort System, this is maybe not as glamorous a mission but it's certainly an important mission for us, and to be able to see that it actually was executed correctly was really neat.

JOHNSON: I imagine it's very rewarding after working those years to get to that point.

If you will just talk for a minute about what you consider your most significant challenge while working with Constellation and then Orion.

RIVERS: Wow, we had so many challenges. Most significant I think I've already talked about. Technically the attitude control motor and its development was the most significant technical challenge that we had to deal with, but the team rallied and did an amazing job. Lockheed Martin, their subcontractor ATK at the time, now Orbital ATK, out of Elkton, Maryland, and all of their vendors and subs like Moog and Fiber Materials, Incorporated out of the Northeast, all these different players just did phenomenal work.

Getting to there was an organizational challenge for us. I haven't really talked about this yet, but when I came on board in January the overall team, NASA, Lockheed, and all of Lockheed's subcontractors, was I guess I would define it as dysfunctional. There was a lack of trust between the groups and so they were challenged to work together and overcome their issues. We had issues at every level. We had challenges between Langley and Marshall Space Flight Center in our relationship working together. We had challenges between NASA and Lockheed Martin as the prime contractor and our ability to work effectively together and trust each other.

Back in 2009 Lockheed Martin had contracted with Orbital Sciences to be the primary integrator and developer of the Launch Abort System. They actually had subcontracted with all of the various vendors for the different subsystems. There was a challenge with the relationship between NASA and Orbital and Lockheed. Our NASA engineers obviously, they wanted to get down on the ground and talk to the engineers who were developing the subsystems. But you can just imagine contractually you've got Lockheed contracted by NASA, Orbital is contracted by Lockheed, and then Orbital has subcontracts with ATK and Aerojet and other companies. That's a complicated communication train and it's complicated lines of authority and responsibility. It certainly hindered our trust for each other frankly.

We spent a lot of time in 2009 in the midst of trying to resolve all of our technical issues working on building that team and helping them to cohere together. It was a big organizational challenge frankly.

Then after Constellation was canceled, Pad Abort 1 was flown, and then we were reconstituted as the MPCV Program, we had overcome a lot of those challenges and were working together as a team, which was demonstrated in the successful Pad Abort 1 flight test.

But we still had trust issues and challenges. Mark [S.] Geyer, the Program Manager, came in and said, "I want to implement a new model of how we work together, I don't want to have a large NASA team overseeing the contractor and checking their work on a daily basis. I want the NASA team to become embedded with Lockheed and produce products itself so that we can gain this insight through doing in-line work." We were faced with a new challenge at that point, and that was to go from how we had figured out how to work together up through PA-1 and now we had to figure out a way to work even more closely together and trust each other. It was organizationally challenging to say the least, but it made for some very fun workdays.

JOHNSON: You said that you all worked towards a solution to that problem, but was it an organized effort to make that system work better? Or was it just that on the management level you all decided that this needed to be done?

RIVERS: I would say when I came on board in January of '09 it was the latter. The team was not working well together. They didn't trust each other. There was a lot of animosity I guess between folks, frustration may be a better way to say it. Lockheed felt like they were getting cut out because the NASA engineers were trying to talk directly to the subcontractors. NASA felt like they were not well informed because things happened at those lower levels without their knowledge.

Honestly what we had to do on a couple occasions was just get the whole team together and sit them down and as a group work through how we were going to work together. What were our rules of engagement? What were our communication channels? How were we going to raise issues without throwing individuals under the bus? How were we going to be inclusive at all these different levels so that we had people that didn't feel like they were purposely being left out of the conversation?

We did a lot of that. Frankly, we did a lot of that in the throes of resolving the technical challenges that faced us. The good thing was we were able to get all of the group to understand that we had this common problem and we had a common goal. Frankly a lot of the NASA guys came in and said, "Well, Lockheed is only here for a buck." Obviously they're a commercial entity and they need to make profit, but that's not what drives them. They're engineers and explorers just like the NASA folks are. They had to learn that about each other.

When they did have issues they could go back and remind themselves that, "Hey, wait a minute, we disagree on this, but we do have a common goal." Resolving the technical challenge of the control motor, or demonstrating pad abort in PA-1, or demonstrating nominal jettison in EFT-1, or whatever the focus was at the time.

I led the team through that, but I don't believe that I had any magic dust that I sprinkled on people, I just tried to keep them communicating and help them build relationships and help them stay focused on the common goals. Then obviously helping them to address communication challenges when they arose to enable them to be successful.

JOHNSON: Do you feel like once Mark Geyer said that NASA needed to be embedded, and the engineers then started working more closely with the Lockheed engineers, do you feel like that solved a lot of those problems just by getting people side by side?

RIVERS: Yes, absolutely. I was involved in the Shuttle Return to Flight activity back in the 2004, 2005 timeframe. We had a lot of similar problems there. What we had to do in that situation was we would ceremoniously lay our badges on the table so that we could work in a badgeless environment.

We repeated that on this activity to remind people that, "Hey, look, yes, you're a government official, you have a responsibility to do some things, but you're a part of this team as well as these other folks." To first humanize people and help other people understand that human beings are human beings. We make mistakes, we have aspirations, and we're not some entity that's just motivated to bilk the government for money. Once we overcame that, then we had to overcome the contractor's resistance to having us engage, because if you can imagine, it's like you invite me to dinner and on the way I call you and say, "Oh, by the way, don't start cooking, because I'm going to help you." If you don't know anything about my ability to cook, and you also know that I'm now going to come in and use your pots and your pans and your products, you're going to be a little nervous about the situation.

What we did on my team, what I did, was I carved off little pieces for the NASA folks that I felt they could do them, they could accomplish them, they could demonstrate their abilities to Lockheed Martin and their subcontractors, and in the process build trust. It worked, they did those things, and they were successful, and Lockheed saw their value, and Lockheed actually started asking them to do more and more and more and more and bigger and bigger and ultimately fully engaged them.

I believe that that still goes on today on the team. I check in every once in a while with Robert [J.] DeCoursey who took over for me, and that's what he tells me when I talk to him.

JOHNSON: Did it happen across all the different areas, not just Launch Abort System, but as far as the Orion itself with Lockheed Martin and the contractors?

RIVERS: It did. I like to brag that our team, we're the tip of the spear, top of the rocket. We led the way. I like to brag about that. We did lead the way on this. Because we had already been through the fires on pad abort, it was easier for us to get to that place than the rest of the vehicle team. Frankly Mark Geyer used us as an example on many occasions of how he would like to see the overall team working. I believe they've gotten there today. I think on the crew vehicle side they had already carved off several systems and said NASA is doing this and they're going to provide it as GFE [Government Furnished Equipment] so that those teams really just kept focusing on what they were doing and continued to do that. But in other areas, like in the structures area for instance, I see the NASA and the contractor teams working well together.

It's interesting. We weren't really the tip of the spear on this. The systems analysis folks, the folks that were doing the trajectory simulations, the flight dynamics, and building the aerodynamic databases, they already had been working as a badgeless team prior to that change. So they had already worked out a lot of those issues and were working well together. I wouldn't say that we invented the way to do it. We looked closely at what they had done, and that allowed us to optimize and move forward.

JOHNSON: I just really have one more question. I know you mentioned some of the challenges that you had, but what do you feel is your most significant contribution?

RIVERS: Me personally, I believe that I did rally the team to coalesce and focus on the challenges that were in front of them and be successful. I don't like to brag about myself, but I do believe that I enabled that through my leadership.

JOHNSON: Is there anything we haven't talked about that you'd like to talk about?

RIVERS: No, ma'am, I can't believe I talked for a whole hour.

JOHNSON: A little over an hour actually. I appreciate you taking time out today, and I hope we didn't run over too long into your schedule.

RIVERS: No, we're good, thank you so much.

[End of interview]