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INTERVIEWED BY JENNIFER ROSS-NAZZAL
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ROSS-NAZZAL: Today is July 6, 2018. This interview with Jonathan Homan is being conducted at the Johnson Space Center for the JSC Oral History Project. The interviewer is Jennifer Ross-Nazzal. Thanks again for coming by.

HOMAN: Thank you, Jennifer, for inviting me.

ROSS-NAZZAL: I wanted to ask about your memories of the day that the [James] Webb [Space Telescope (JWST)] finally arrived [at JSC]. You'd been working on this project for so long. Was there a big celebration?

HOMAN: There was a lot of hype when it was going to arrive. We knew it was going to arrive sometime during the night. They were being very restrictive on the paths. In fact, I think they did a dual-path type of thing. Like this is what they let leak out, then they came a different direction just in case.

ROSS-NAZZAL: Oh, didn't know that.

HOMAN: There were only a few approved routes anyway from Ellington [Field, Houston, Texas] to Johnson. Of course it landed on the [Lockheed] C-5 [Galaxy aircraft], and our teams went out there, got it, and then the transportation team brought it onsite. It was probably about 6:00 in the morning—no, may have been 2:00 in the morning when it arrived. I can't remember, but it was in the middle of the night or early morning. Maybe they took off at 2:00.

Even though it's coming from Ellington, it takes about two hours because we had to work with the Houston and Webster police departments. They were both very good to work with in terms of moving power poles. They were rated to only go at about seven miles an hour, maximum speed. We did use Space Center Boulevard. Some of the roads off of that allowed easy access in the middle of the night, where they didn't have to worry about traffic, and they could also do that.

I did not go and watch any of that when it first arrived. We did have some folks who did. I did verify when it arrived in the morning that it was at Johnson, to make sure I could send a note out to Johnson management to say, "Hey, it arrived." A lot of hoopla leading up to when it was going to get here.

I'm not sure if you signed up for one of our tours, but we were going, "Wow, once it's here we're going to probably need to do more tours." A lot of people wanted to see it. We started just advertising first through the *Roundup* [JSC newspaper]. That got a little crazy, so we tried to do a shared folder where people could sign in. I think we had five months fill up in about 90 minutes. We were filled, and a lot of people were disappointed because they weren't able to get a tour. For all the people who did get that, we did hold those obligations. A lot of times people would just try to tell people, "As long as it's not more than 10 additional people, come." We would expand the tour group so that we could pull some more folks in.

There was, yes, definitely a lot of excitement. Of course when it arrived we did a media day with [JSC Center Director] Ellen [Ochoa] and [JWST Program Director] Dr. Eric [P.] Smith from [NASA] Headquarters [Washington, DC] and some of the other program [folks]. [Nobel

Physics Laureate] John [C.] Mather came as well. That was a really neat time when they were all here.

For me I wasn't like, "Wow!" I was more like, "Okay, we've got a lot of things to do." That was my mentality, where there were other people who were just so excited that it was coming. I was like, "All right, just make sure we have everything that we said we were going to have in place in place," all the additional safety equipment for even ambient operations. Anything that could go wrong, we wanted to make sure we had covered.

ROSS-NAZZAL: I had wanted to ask—I haven't seen one, but I know a lot of folks who work on these tests, not always, but sometimes, there is a patch associated [with the event]. Did you guys ever come up with a patch for the test?

HOMAN: They tried to come up with an OTIS [Optical Telescope/Integrated Science instrument module] logo. There are some OTIS things floating around, but they did not come up with a patch.

I'm not sure; I think that was a decision from the program management. They didn't want to go beyond the James Webb too much and focus just on this OTIS test. There were some ideas that had floated around and stuck. Some people had ideas but never anything that became official. They just wanted to keep it at the JWST level. So no, we didn't have our own patch.

ROSS-NAZZAL: I hadn't seen anything, but I thought I would ask. I was thinking about some of the Apollo tests.

HOMAN: That came up and gained a lot of momentum. I'm not sure if it was Headquarters or just the program management said, "No, there will not be anything associated with OTIS independently or the OTIS cryo [cryogenic] vac [vacuum] tests."

ROSS-NAZZAL: Did you ever get a chance to work on the floor of the SESL [Space Environment Simulation Laboratory], or were you primarily just working in ops [operations] once it arrived? Did you ever suit up in a bunny suit [clean room suit] and get a chance to go in?

HOMAN: Once it arrived, I did not suit up in a bunny suit. I definitely suited up in a bunny suit before it got here. I'm trying to think if, when we had any incidents, I went in. I don't think I did; I do not think I went in. Because of my background with the cryogenics I guess I did sometimes have to go into the chamber and check on certain things I was more familiar with than some of the other engineers, but once the flight hardware arrived I did not.

During the pathfinder I usually was one of the people who did a closeout, walked around all of the hardware, and closed it out. We did that with the flight hardware and the flight test as well, but we had more of an escorted group. We had a very controlled group of people who went in and locked each section of the chamber as they walked out, which is what we would do for the other hardware. It was a little more stringent, and a little more controlled by the program on who had access.

Everybody had to take a special training to be in the vicinity of the flight hardware. A lot of the hardware we're used to here at JSC is robust. We're used to humans interfacing [with it so] it's pretty tough and strong. This is highly ESD [electrostatic discharge]-sensitive, highly fragile at certain locations. You don't want to be that person who decides to lay their hand on something and then you realize that, "Oh no," that wasn't made to even take the force of your hand laying on there. There are parts of the spacecraft that were extremely sensitive, so we tried to avoid any Johnson people making direct contact with the flight hardware.

ROSS-NAZZAL: I hadn't thought about that. That would be a bad day.

HOMAN: Even when we had to go in and do our instrumentation we typically—just a liability thing—had one of their integration engineers go in there and escort us to see what we're doing and make sure people aren't getting too close to the hardware.

ROSS-NAZZAL: It's an expensive piece of hardware to replace. Major delays.

HOMAN: Of course they're experiencing that now again, not so much on the parts that we tested.

ROSS-NAZZAL: We talked about the OGSE [Optical Ground Support Equipment] tests and the thermal test. We didn't talk about your role in the actual cryo vacuum test. Do you want to talk about that?

HOMAN: Sure. For the cryo vacuum test, leading up to it—I had been the project manager before then, and I was the project manager for the overall JSC JWST operation. We did have dedicated test directors who helped write the procedures for the facility operations and worked with the program on their profiles and what they wanted to do.

Of course the program had their own test team because they actually had individual large procedures for each of the science instruments, each of the different parts of the optics that they wanted to control and test, and then for all the GSE [ground support equipment] that would be supporting it and all the analysis that they would be doing. So they had a lot of huge procedures that worked off a master procedure, and our procedure at Johnson tied in with their master procedure.

Really it was managing and leading the group. Of course we had the team here at Johnson that was actually executing everything, and I was interfacing with the program management on cost, budget, schedule-type things. Then of course any technical problems they had, really tried to understand it and see if we could provide the solution, if it was something related to using facility-type resources. Does that answer the question?

ROSS-NAZZAL: Yes.

HOMAN: I did take roles during the test of actually sitting shifts either as a test director, or sometimes rarely as a cryogenic engineer, but I did that at times just for coverage. It ran for 100-some days, and we had to fill in three shifts a day. The cryo guys had to fill in for about 130 days. It was a long time that they were on-call and operating the facility.

ROSS-NAZZAL: You want to talk about those two different roles and the difference between them, and what you would be monitoring and doing during those shifts?

HOMAN: Sure. The JSC test directors—we have test director groups. People who are trained as test directors are certified to do different tests all around the Center.

Because we were shorthanded, a quick note on that, we actually contacted the structures group and pulled in a couple of their test directors and trained them on our facility to get more bodies. We had so many shifts to cover. We tried to do a situation where, especially if you're doing the midnight shift, we all took rotations so you didn't have to do more than two or three days in a row, unless some people [liked] that.

For me it was really challenging because I got a period of time where I had several second shifts, which would be 4:00 to midnight or midnight to 8:00 a.m. It seemed like it was hard for me to interface with what needed to be done during the daytime, so I tried as the test went on to get out of a lot of the night shifts, just because it did interfere with more of the project manager-type of duties I had.

The test director for this test—we were operating primarily the chamber. We were working with the program and their overall test plan to create the chamber performance. The test director is over the personnel safety of everybody there and the operators that are here at the Johnson Space Center.

We had data systems, instrumentation, several different cryogenic operators, vacuum systems operators. We probably had a team of maybe about 10. The test director is directing that. With those operators—because the criticality of the thermal systems is so important, and they're complex—we actually had cryogenic engineers on shift pretty much throughout the flight test. It became such an important role, because what we found is as a facility test director—every shift when you first came on, you get the report from the other facility test director, but then we'd have a handover meeting where we all got together. You got a handover from the program test directors and all the GSE people.

The start of every shift we had everybody come together, get it recorded. "What was accomplished, what are changes," and everybody went around the room real fast. I may have told you we had 40-plus people sometimes. Sometimes this room had like 70 to 80 people just crammed in there waiting to give their handoff more officially, and then people would leave after that.

As a cryogenic engineer, what you would do is pretty much interface with both the facility test director—because that's who you directly took direction from—but most of the time we were working with the thermal engineers who were on shift for the program. They were monitoring what was going on, and the cryogenic engineer would help create that environment or make any adjustments to help the spacecraft or GSE achieve the desired temperatures or stability or anything like that. So we were working with the operators, giving them direct direction. Stuff that you can't put into a procedure, but you can say, "Make these adjustments." We weren't changing any code. It was more changing set points to either achieve a certain rate of, "Hey, let's watch this drift," and change temperature over a period of time in this one area and see how the spacecraft reacts. We would create a certain environment for them for a period of time over a shift. Or sometimes some of them were a week, where you're either raising temperature fast or slow or trying to hold.

We had a thermal stability where we actually held I think 0.02 [degrees] Kelvin over a period of I'm not sure how many weeks, but it was over a pretty long period of time. That's pretty amazing; [that's] how great the facility operated, because we actually asked, "What temperature did you guys want?" We could have gotten colder. They decided to hold the environment at 20 Kelvin. They wanted 20.00, and we fluctuated between 19.98 and 20.02.

The control systems weren't as precise to hold that. A lot of times you needed somebody to see what was going on, because even just the temperature of the day and night outside could cause the systems inside to fluctuate more than that. You were reacting to seeing how things were going and making slight adjustments to try to make sure that they had extremely flat steady temperature for them to do their thermal balancing, and see how their heat transfer worked across the spacecraft without being affected by the outside environment.

ROSS-NAZZAL: That's interesting. They had sensors all over the Webb, so you were able to tell?

HOMAN: Oh, yes. They had lots of sensors on the Webb. We have a lot of sensors on our shrouds and the GSE that's all in the chamber. A lot of data, a lot of data.

ROSS-NAZZAL: Were you working with Tony [L.] Whitman and Lee [D.] Feinberg when they would come to you and ask about these sort of things?

HOMAN: Oh, yes. Lee of course is the optical lead for James Webb, and he's essentially an optical expert for the Agency. Tony is one of the leads at Harris, both in systems engineering and in optics. Both of them took positions as test directors for the spacecraft. I've definitely worked with both of them, especially Lee, over the years in terms of different things. Lee was really the owner of the optical data from this test. Another gentleman, Stu [Stuart D.] Glazer, was the owner of the thermal performance during this test. Those were, for me, my two customers technically.

Mark [F.] Voyton was my direct customer from a general cost, schedule, and somewhat technical. But since Lee really owned how the performance did, and how it affected the optics, and he had to answer to the performance of the spacecraft optically—and Stu had to answer to the performance of the spacecraft thermally—we definitely took a lot of direction from them and tried to understand what they needed and react to it.

ROSS-NAZZAL: Were there any major challenges with the facility? I know we talked about [Hurricane] Harvey, but were there other challenges that you recall?

HOMAN: It's one of those things. You plan a family vacation way out in advance because the test is supposed to happen in March, and of course it slips to July. I had a vacation, and I definitely had to answer some things. When we first started, one of our big pumps that we had recently just refurbished burned up a belt, I think. It burned itself up really early on, so we were able to repair that and not delay the test.

On the facility, there's the large cooling towers that you probably have seen if you've ever driven by [JSC Buildings] 32 and 36. They provide a lot of the cooling of the water at ambient temperature. We had something go wrong. We lost both of those towers for a short period of time. Again, the facility folks were able to get in there and fix them, and we were able to actually get very reliable operation for the rest of the test.

Of course that stuff all happened pretty early on, so that was good. And it was before we actually started cryogenic operations on the chamber. We had actually fired up our cryogenic systems, and they'd been running in standby mode just to make sure that we didn't have any problems. Because you have these huge, massive pieces of highly complicated hardware, when they're off and you turn them back on, that's usually when you find your problems.

Once they're running for a period of time they're very reliable, and the problems work themselves out. That's what probably happened, because we had purposely—and we do this purposely—operated all the vacuum systems right before the test. Three months before, a month before, and a day or two before the test, to make sure everything's running fine. But you go into the test and one burns itself up. You know, you try your best. There's enough redundancy in there that even with the one pump down it didn't stop us. It did slow performance down for a period of time until we got it repaired, but it didn't affect the overall schedule. That was the same with the cooling towers; it didn't affect the overall schedule.

After that, I can't really even remember. We got a lot of praise, because really the facility was rock solid for the flight test, especially once we started the cooling of the spacecraft and cooling of the chamber. We really had no technical issues.

I may have mentioned during Harvey we did have the scare, we stopped getting deliveries of LN2 [liquid nitrogen]. I think I explained that last time. That was a potential scare, but we didn't have to implement any of our procedures that said, "What do we do once we get to a certain level?" We were always able to hold above the critical level to say, "We can continue with testing."

On the spacecraft—I may have mentioned this too—we did have an anomaly that started up pretty early on. We started noticing that when we started cooling to a certain point, a cyclic astigmatism that would show up. Every 24 minutes or 30 minutes, it would come on. We eventually were able to tie it to the operations of a certain flight heater. It did take a long time to figure out. It was really towards the end of the test when we were down on the ground and understood what we thought the problem was. We eventually thought, "Okay, it doesn't have anything to do with the flight design. It's the way we're doing our gravity offloading." We had Building 10 manufacture a new part.

We were able to go into the chamber, change out that part, and go back into a quick test and prove that it was that. That was a huge "wow," because it would have been a big deal if it really was a flight design, like maybe a cable harness was transferring heat which was causing a thermal distortion. We looked at a lot of different things, and it was a top priority for the program to understand, "What is this?"

Slight, "every time this heater comes on we lose focus." Because of the adjustments of the mirror they could refocus the mirrors and get them back aligned, but then every time the heater went off, you had to stop and redo that again. It would have been something that they maybe had to look at going into the spacecraft, tearing parts apart, fixing, and going back in, which would have caused a major delay on the OTIS portion, the optics and the science instruments. But that wasn't the case, so that was great.

We did have another issue that turned out to be with the photogrammetry that shoots all the pictures and lets us do the cryo positioning and see how things are moving with time and temperature. We had one mirror that wouldn't fully phase, and again it turned out to be a photogrammetry target that was put on for the test, the way it was reacting. Probably about the force of maybe a finger pushing down on a piece of paper and deflecting it. It wasn't much force on there, but it was enough that these actuators could not get that one mirror to phase. That was actually something we figured out during the hurricane, so that was a cool thing to go, "Wow, that really helped to understand what the problem is," and realize again it wasn't a problem with the flight design. It was a problem with some of the additional instrumentation we added to the spacecraft to do the test.

Once we were able to get in there, take that off, we could see, "No, the mirror is phasing just fine." It sounds bad, like, "Oh yes, you're deflecting it." But really you're not damaging anything. You're trying to adjust these mirrors by nanometers, and you're creating just a really slight resistance so it's not able to change those few nanometers. Once that one mechanical restriction was removed it was working just fine again.

ROSS-NAZZAL: Just to clarify, you went into the chamber to fix these two things during the test? Or did I misunderstand, was this during pathfinder?

HOMAN: No, these were during the flight test. We finished the flight test on October 17th where we actually were back on the ground. It was like a Saturday. We were on the ground, I think Sunday it was safe to go into the chamber. But we had two essentially discrepancies against the flight hardware that we needed to solve.

We were able to pretty well deduce what the one was by just doing some analysis, and people on the ground doing some thinking and going, "I think it could be this one little clip." We were able to make that adjustment, and while we were still in the chamber do a quick—we didn't do a full cryo vac test, we just did a test of all the equipment that way. Then we did have to do slight thermal. We kept the thermal systems running. Like I said, we were actually in test then, with the main door closed up until the weekend before Thanksgiving of 2017.

The other one took a little bit more time. A lot of people had different thoughts like, "Was it a cable harness? Was it the flight instrumentation? Was it test instrumentation carrying the heat back and forth?" Finally somebody said, "I think it could have been one of the offloader reactors that just didn't have enough clearance, and at a certain point it would make contact and transfer that heat and deflect the mirror."

It took a lot of time. We finished October 17th or 20th, somewhere in that range, and we didn't open the door till the weekend before Thanksgiving. That was somewhere in that 23rd, 25th [time period], so may have been the 19th or something that we finished. We had another full month of working shifts and meetings constantly of what we thought the problem was, what we could do, and get back in and do it again.

We were doing a test run for a day or so, stop, figure out the data we had. "This didn't work. It wasn't the cable harness. It wasn't this, it wasn't this, wasn't this." Finally we were able to find the problem. At the end you realized it had nothing to do with the flight design, which was great. It took a concerted effort of a lot of people to really find the solution and prove that that was the problem and that the spacecraft itself was designed well and is working well.

ROSS-NAZZAL: Were there any changes that had to be made as a result of the test, to the hardware?

HOMAN: Not that I know of. There was some redoing of thermal blankets, but I don't think it was necessarily a design change as it was removing, looking at how they were laid, and then laying them back on and reattaching them. A lot of them are attached with just [Kapton] tape, but it's an art form. You don't think that this flimsy silver, plastic, aluminized Kapton, or sometimes they have the black Kapton, [will protect the telescope]. If you attached them just wrong, or things were moving and shifting as they change. You found a few areas that probably needed a little bit more time to create a little bit more stress relief. That was one thing that we went back in and had to make a few adjustments to the thermal blankets, but nothing had to be redesigned on the flight hardware that I know of. That was good.

ROSS-NAZZAL: That's a relief. I know talking with Lee Feinberg, he was talking about Hubble and how this test was so important because of Hubble and what they were looking at, and making sure all the i's were dotted and t's were crossed. What are your memories of bringing out the Webb and getting her ready to go on to her next phase?

HOMAN: One, I was really relieved. Of course being the project manager, I got a little nervous financially when we had budgeted and scheduled for the test to finish probably early October, then we didn't finish the one part until mid-October. And really didn't get out of test with a lot of guys, our JSC folks, on shift until late November, and I'm having to pay for a lot of safety equipment—so there was a little "yay!" I felt relieved, like, "Wow, the test is over, and it was successful."

At the end, once we found that last problem on the mirrors—we had to run our thermal system to give something for the heater to actually click on. It was just really good to feel like "Wow, it's coming out!" It was probably about as successful as you could possibly be.

If you talk with Lee, they were very happy that they met or exceeded all their requirements. They had a lot of quick look. We had a lot of the analysis. They were able to do a lot more detailed analysis, and everything looked really good on the optical performance of the telescope. Great thing about it too is once we had it there and we were able to do the open house.

ROSS-NAZZAL: Oh, I went to that one. That was crazy.

HOMAN: Yes. I think right before the open house we had the mirror—no, it's not. It was after the open house, because we were trying to get a schedule in there. This was something I was really happy about with the telescope being at Johnson. I've already heard from the contamination folks. The contamination levels both in the chamber and the clean room were amazing. The facility was great, and the performance was great.

Not only that, but because it left in early February, we were able to take some time while they were working on some other things to flip the spacecraft over, after the open houses, with the mirrors all stowed and clean them again. They went through a really rigorous cleaning process.

Essentially they almost cleaned about an inch of each mirror at a time, but had a bunch of people. It went faster than we thought. We were able to take about a week and get all the mirrors cleaned, get the thing really well cleaned up, so that when it went back into its storage container it left the Johnson Space Center cleaner than when it got here. I was happy about that and felt really good that we had that opportunity to do that.

That was a risk coming in. "Oh, you're going to be at the Johnson, you're going to be sitting faceup for all this time. It's just going to be collecting dust and contamination. The time at Johnson is going to deteriorate the overall performance of the spacecraft." Well we exceeded our requirements for contamination so that didn't become a problem, and they were able to use the time here to actually clean it up so well that it has a lot more margin now that it's out in California. I think they're possibly struggling a little bit on their contamination. Yes, a little bit more. I think their clean room doesn't have the performance, what we had here or at [NASA] Goddard [Space Flight Center, Greenbelt, Maryland].

ROSS-NAZZAL: That's great. That means that JSC's reputation is increasing in terms of telescope or other hardware tests.

HOMAN: Oh, yes. From how things went, I think we exceeded all our requirements. Which is always a nice thing. Thermally, whatever they wanted we gave them. It saved them a lot of time and a lot of money. Contamination we saved them. Vibration maybe we struggled a little bit. We did have some vibration issues that showed up through the pathfinder tests and caused some redesign on how we were doing instrumentation.

We actually had to create a longer path for all the cables, and the path would have vibration isolation intermediate along the way. Because we did find that yes, if we had them on the floor, even though the spacecraft was actively being dampened, the vibration from the floor was getting through the instrumentation cables and causing a little bit of disturbance. Fortunately we were able to find that out during the pathfinder test, [and then] redesign some hardware to extend the length of those, and create more dynamic break points.

ROSS-NAZZAL: You've given a lot of really good examples, but I wonder are there other lessons learned that you would pass on to folks that are undertaking a test of this magnitude? Lee was telling me he thought the test was the greatest engineering hurdle ever; he was really concerned about it.

HOMAN: Yes, some people talked about this was possibly the most technically complex test that was ever put together.

This is just from my perspective. I learned a lot working with these guys, because a lot of times you have a solution and you work with the major program and there's always cost constraints. Either you have your fiscal year constraint, or you have an overall budget constraint. A lot of times it's like, "Oh, we need to do this. We need to do it now, but that money won't be here till later."

On the Johnson side, one of the things I learned is designing things to be extremely reliable and efficient doesn't need to cost more. We were able to create a lot of flexibility into the design. We designed stuff to know that if we want to create a Martian surface or a planetary-type surface or a Moon, the chamber has that ability to get those temperatures, create that environment, and handle most of the heat loads.

We could put Orion [Multi-Purpose Crew Vehicle] in there, we would be able to do an Orion test without any issues. If we wanted to put a lunar or Martian hab [habitat] module in there, we would not have an issue to do the thermal loads or the thermal profile that would be required.

That was just a testament to really being involved early. Being involved back in 2004 and designing the test, "Wow, this is going to cost a lot. Let's redesign the test again." Spending from 2004 to essentially late 2006, maybe even 2007 working on the design of what the chamber needed to be, while also designing how they were going to test the telescope.

Going through that iterative process and working together really helped, so that when we actually really were given the go—when [NASA Administrator Michael D. "Mike"] Griffin signed the thing late in July of '06. The next year you become a project at Headquarters level to say, "Get it done, you have so much time." That really helped, being able to do a lot of the engineering up front, and do the iterative process and develop those technologies early, so that you understood them later on.

The pathfinder test—there was OGSE-1, OGSE-2, and the thermal pathfinder. But we did the chamber functionals 1, 2. We did the bakeout of the chamber; we did the cryo proofloading of the GSE in the chamber. We did two other tests, so before we ever got to the flight test—I have eight on my fingers here. I'm thinking it may have been closer to 10 tests we performed in the chamber, and they really helped us wring everything out. The problems we had with the pump, it wasn't a problem with the design. It wasn't a problem with meeting test objectives. It was, "Oh, something went wrong," fix it, we're back in business.

Some of the pathfinder was like, "We're not quite getting there." The vibration became an issue, "What's going on? Why are we scratching our heads? Okay, is it coming down from the top down? Where is the vibration coming from?" Having that time to be able to work some of that stuff out.

We had some thermal control issues, and we were able to solve those through the thermal pathfinder working procedures. Really every test we did probably had a slightly different thermal profile, so being able to understand when we got into the flight test how we were going to manage it. That's one of the reasons why we put engineers on shift and had that communication, too.

That was the other thing that really worked out well, the cohesiveness of the program at Goddard, their Goddard site contractors, and the program prime contractors—and the Johnson team with all different folks, with our quality, our safety, our engineering support. Working together as a unit took time, and really learning how we would work together took a little bit of time. That was a real good lesson learned as well.

Fortunately, before the flight test—I think I mentioned this—we had plenty of strong thunderstorms that let us have some issues. Did anybody mention to you about July 4th weekend of 2014 or '15?

ROSS-NAZZAL: Not so far.

HOMAN: No, no, may have been '16. JSC wants to do all this energy savings with water around all the buildings.

ROSS-NAZZAL: Oh right, yes, the Flex Friday [and Federal Energy Management Program].

HOMAN: Yes, we have our utilities over there in Building 24, and they've been modifying a lot of things in the building. We've been holding them off at 32, and they're like, "Well, you've held us off for years. We need to do this modification. It won't take that long, we just need a weekend."

We learned a lot there because it was July 4th weekend. It was extremely hot. When they took the water down for the building, we had our emergency systems running. It helped, but the building probably went from like 75 degrees [Fahrenheit] to—we had some areas that were well over 100 degrees in the building. We learned, "Wow, our data system is going to need even more cooling. Certain GSE thermal racks need additional cooling."

During that weekend, we had the chilled-water outage and the air-conditioning outage. We brought in additional spot coolers. We opened up rental to local facilities, and we got a lot of stuff in here and ran it off of our systems. Fortunately we weren't out of normal power, so we could run things off regular power, but we also ran our large thermal backup systems.

They helped with the chamber and the clean room, but they were not able to hold it within specs [specifications]. There was no flight hardware in there at the time, but that was a major lesson learned that we were like, "Wow! When it's in the middle of the summer and the power goes out, these buildings get really hot, especially if you have a lot of electronic equipment running in them and no active thermal control." That was a lesson learned, and we were able to have that happen before we had potential of a hurricane.

Fortunately, with Harvey we didn't have a power outage where we lost air-conditioning in the building or flow of water in the building, so we didn't have to bring on all those type of systems. But we brought in a lot of dehumidifiers, large roll-around dehumidification units. We built tents around certain hardware.

So, we were really well prepared before the flight test came. We had a lot of equipment. So even when Harvey came—you may have seen the pictures of the tents we built around a lot of the computers.

ROSS-NAZZAL: I did, yes.

HOMAN: We built tents around different things and had a spot cooler in here and a dehumidifier over here. It was just cooling and dehumidifying to keep things within their thermal and environmental control. That's all on the safety things.

Because the test was successful, people will not know how much energy went into really making good decisions on the redesign of the chamber. There was a lot of energy and a lot of time spent really hashing it out before we started buying equipment.

A lot of pushback from the program, just always, "Oh, if you can do it, get something smaller thermally. It'll save us money." You'd have to almost do the trade study and show people that there's not a big price change from this much performance or this much performance, especially when you start actually having to modify buildings. The price difference is the hardware. There's so much more involved in the installation and operation than there is on that. I was glad that we always—I wouldn't say we oversized, but we worked with them on requirements to make sure that we didn't underestimate anything, because we used all our performance at times. So that made sense. It took a long time to really do that.

Maybe I mentioned too about our thermal zones on the helium system. We had proposed doing 30. They didn't like the cost, so we came down to about—I think we had 15 at one point. We had, I think, seven, seven, and one spare. By the time we got to the flight test, we had built three more zones. Every time we used the spare—it was too bad because it was good work because it added on, but it would have been better if all that had been designed at one time. Could have been a little bit more efficient, but it wasn't bad not doing that.

Same with a lot of the emergency power. We ended up doing a lot of upgrades to safety systems not during the chamber modifications, just due to cost, and doing it through the pathfinder phase, which put more pressure on us on the Johnson side. Because now we had a major facility modification to do with a major test, at least pathfinder test, holding us to our schedule. It was always a good driver for keeping things moving.

ROSS-NAZZAL: Was that a challenge? You work for Engineering, and Center Ops [Directorate] usually does things like that. Was that a challenge working with two different orgs [organizations]?

HOMAN: Sometimes it was. I would say for the most part I felt like we got great response from Center Operations. They were really helpful. They're really working to get the Center upgraded.

We had to work together quite a bit because they've been doing what they call bus ring repairs and all these major electrical grid repairs on the Center. Sometimes we had to just say, "You can't do certain ones, because they've got our building, and we've got critical hardware getting ready for a pathfinder test or getting ready for the flight test." We were able to work things out, and work outages out.

For me, I would take their information, try to understand those [risks]. Put together a set of charts to describe the risk to the Goddard management, who would say, "You're going to have to—." [I would explain], "Really JSC needs to do this, and we can't always say no. We've got to start saying, 'Yes, let us understand the risks and see how we could posture ourselves.'" Because we had so many safety systems, when they would take different power or do different outages, we were able to run our systems and provide that as a backup.

When the flight hardware was here we never took that approach, because we never wanted our backup system to be primary for flight hardware and have to rely on the Center power to be put back on. We were able to work through the years of doing that, and I felt like Center Operations was very understanding.

Before the flight hardware showed up, they started bringing over a full-time [crew]. We'd have an 8:30 tag up meeting with some of the critical program folks and the JSC team. We had an earlier morning meeting where everybody knew what the tasks were, and then this was we had Jacobs [Engineering Group] folks, Center Ops folks, Harris [Corporation] folks, Northrop Grumman [Corporation] folks—different folks all working, "Who's working and where," so we weren't working on top of each other. It was a little bit of a safety or just a work coordination meeting.

Center Operations started bringing people to that meeting, and higher-level folks through the years, especially when the flight hardware arrived, to really make sure that if we needed something from the utilities here at the Center they were able to adjust that real-time real fast or get the response we needed.

With the construction of the chamber, Center Operations did a lot of the modifications to the building, did all the high-power connections. A lot of the unpowered infrastructure changes, we were able to use some of the engineering support to actually run the wires, but they could never make the connection to the actual high-power system. That all was coordinated really well. They worked really well with us and supported us well on that.

The rigging support is out of Center Operations. They actually worked hand-in-hand with the team at Johnson through the Construction of the Facility and just rolled right into getting the chamber GSE, working with the program partners, and working with them on a daily basis for 10-plus years. It was good support. The program appreciated their support, and we definitely appreciated all that they did, because we had a lot of challenging large pieces of equipment to move from ground level to 100 feet up in the air. It wouldn't fit in an elevator—hit the button and come out—you had to come up with unique ways to do this. So they were highly integrated in the project planning and installation of all these modifications we had to do. That was a great support.

ROSS-NAZZAL: We have two questions we always like to ask people. One is, looking back what do you think was your biggest challenge for this test? You were working on it for so many years. Is there one that stands out?

HOMAN: The biggest technical challenge—a lot of people have a lot of praise on the modification we did to the LN2 system on the thermosiphon. Looking back, that was a huge modification challenge. Trying to keep that in a cost box was really important, because from the Agency and program standpoint they look at a chamber like that and they go, "You've already got liquid nitrogen. Why should we pay to modify to fix your problems that you have? We just want to use your facility. You ought to take care of your problem." So that was a big one.

The helium system I'm very proud of. I'm proud of the thermosiphon as well, but I think it was extremely efficient. It was so flexible, and more than met the requirements. Some of the earlier tests, we had some leaks. The GSE had some major leaks. It wasn't anything that Johnson could control, it was something Goddard or their contractors had control over.

One of our early tests—I think it was actually the chamber commissioning test, where we commissioned that with the GSE—we actually got a pretty good supply of frozen air on the back of the helium shroud, and you could see it through the viewports. It was frosting up, and all that frost you saw was nitrogen and oxygen freezing out, leaking from a piece of GSE. That was just constantly being fed.

That's always a challenge when you're integrating with a group of people. We try to set requirements from ours to theirs. We try to work together as a team. You can have some influence, but you have no control over how things are going. We had some potential risk of all that air coming off and coming up in pressure so much that we lost thermal control in the chamber.

We had some requirements—going forward again, going towards the flight test—that we could have damaged the flight hardware if all that came off and the pressure rose. Then all of a sudden you've got this convective heat transfer on stuff that is supposed to have really stable, distinctive temperatures. The refrigerator—I told you we were able to control the stability within plus or minus 0.02. With that, we were able to slowly release all that air by just slowly changing temperature.

That was not a requirement given to us, built in, but we said, "This is the performance that we think it has," and we proved it. "Hey, if the pressure got too high we could just drop a quarter of a Kelvin." All of a sudden it would hold right where we wanted it to for a period of time, until all the vacuum systems could maintain it. We could see the pressure coming down, and we could slowly—we referred to it as a burp. I don't know if anybody else has talked about the burps in the chamber, but we referred to it as a burp. Other facilities around the world have problems with burping. When you run cryogenic temperatures, you get a lot of frozen air, and when you start warming up all of it flashes off really fast. You get this really large pressure spike, and it causes a lot of problems.

We didn't have to worry about a large pressure spike, because of the helium system, it was really great. We were able to show that we can create an environment in the chamber from 15 Kelvin up to about 330 Kelvin. Like I mentioned before, if you want the surface of Mars to be at 70 Kelvin, we can do that. If you want a lunar one that's at 100 or 300, we can create that in there without having to modify the chamber again.

I do know that there's some telescopes that want to go colder. Seeing the performance of our refrigerator, we could do some modifications to those to be able to get temperatures down into the five Kelvin [range]. It would take a lot more to probably get in the sub-five, like a linear accelerator where they're running in that 1.7, 2 Kelvin. Then you have to do some special tricks with the helium to get those lower temperatures, and it usually requires large equipment. That would be a challenge if we had something else in the future of the facility, but I don't see anything driving the sub-10 Kelvin—I hope—in the near future. Creating 15, 20 Kelvin is way beyond lunar, low-Earth orbit. This is creating a nice deep-space orbit, something that is going to be far away from the Earth and Sun.

ROSS-NAZZAL: Very cold.

HOMAN: Yes. I don't know if that's a challenge that was overcome, but I definitely look at that helium system and think that it's something that I was very proud of here because it doesn't exist at other facilities, especially the performance that it has and the range that it has. Other people have cryorefrigerators. You just turn them on, and they come down to a temperature, but they have very little control. Where ours is, "Tell us what you want, and we can get you any temperature from 15 to 300," the way we designed it.

ROSS-NAZZAL: It sounds like you've got a lot of flexibility built into the system.

HOMAN: Yes. It does take a lot of knowledge to do, because it's a lot of heat exchangers, a lot of turbines, a lot of things working. But it does have a lot of knobs you can turn to have some flexibility.

ROSS-NAZZAL: What do you think is your most significant accomplishment when you point to this test and tell your colleagues or your family, "I did this"?

HOMAN: I felt like the performance of the chamber was resting on me. I don't know if that was fully true or not—we definitely had a lot of people—but I felt like I took a lot of pressure from

Goddard to verify that the chamber was going to do everything it was going to do, both thermally and vacuum-wise. Once we started it up, I was like, "Okay, not everything worked perfectly, but we're going to not just meet, we're going to exceed all their requirements." I felt like a huge burden was off me.

Not only that, we have probably the best thermal vacuum chamber in the world. We can operate it. We had quite a few people here during the flight test because we wanted that kind of coverage and that kind of controlled detail. But if you needed to do something that was more automated and hands-off, we can run that chamber very efficiently and very automated for pretty low cost.

People think, "Wow, it's huge. You must have all these people watching." We have a certain number, and we had probably more than we needed to just do basic operations during the flight test and some of these other tests. But if you knew what you were doing and you didn't have anything that was as critical, we could do a very cost-effective test. Definitely very proud of the performance of the chamber. That was the biggest contribution, of course, getting into the test.

The testing portion, once we knew that, I was very confident going into the testing that we would never have an issue with chamber performance. Once we did more and more of the safety systems and were able to prove all the requirements and additional safety requirements, I felt very confident that we had a plan for everything going into the flight test.

ROSS-NAZZAL: I don't know if you want to take a look at your notes. We're actually a little bit over time.

HOMAN: No, I don't have anything pressing today. With the tours and the interest, I think we did a good job here of 1) making Goddard feel like, "Wow, everybody is really excited about James Webb here." I did feel bad that we tried our best to do these tours, and I still could not believe how many people were not able to find an opportunity to come. I'm like, "We've had thousands and thousands of people come through, and still." That was a little bit of a regret. I don't know how we could have solved that. Maybe if we could have coordinated a little bit better. The program really wanted to maintain schedule, so they gave us, "Here's the windows of opportunities to do these family days." It took a while. We settled on December 20th, and then that one got so large we were asked to do another one. They gave us the 9th and then pulled it back to the 2nd.

Of course I had to be the bearer of bad news to say, "We're going to have to do it on the 2nd," because I knew. I was like, "Look, the telescope is not going to be visible on the 9th because actually on the 3rd we're starting to re-stow portions of the mirrors." That was a little bit of thinking back, like, "What could we have done better on that to make sure that we could support people coming and seeing?"

ROSS-NAZZAL: Yes. Well who knew it was going to be so popular? I was surprised. I went over there that one day, was it December? Whenever it came out of the chamber, and you guys had that big day.

HOMAN: The 20th, that one.

ROSS-NAZZAL: [JSC History Office Manager] John [J. Uri] also went. He was later in the line because he went up to get his family and came back and said that they didn't get to see it till like

8:00 or 9:00. When we left the line was crazy. I got in line thinking, "Oh, this will just take a few minutes, no one's going to be here." The line was already out the door to the sidewalk, I think.

HOMAN: Yes. It definitely was fun to be part of something that was so popular. [I] felt bad because people didn't get to see it. I can understand they were frustrated, because this is an opportunity to see something that hopefully will change science and change the world. How often do you actually get to see a large flight hardware here at the Johnson Space Center? Usually you have to go to [NASA] Kennedy [Space Center, Florida] or a contractor to see something of significant size that's being built.

ROSS-NAZZAL: Yes, that was really awesome. I'm glad you guys were able to do that. Thank you for coming by again today, I really appreciate it.

HOMAN: Yes, hopefully answered your questions, wasn't regurgitation, too much of the same.

ROSS-NAZZAL: No, no, I don't think so at all.

[End of interview]