NASA JOHNSON SPACE CENTER ORAL HISTORY PROJECT
EDITED ORAL HISTORY TRANSCRIPT

THOMAS R. SCORSE
INTERVIEWED BY JENNIFER ROSS-NAZZAL
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ROSS-NAZZAL: Today is August 1st, 2018. This interview with Tom Scorse is being conducted at the Johnson Space Center for the JSC Oral History Project. The interviewer is Jennifer Ross-Nazzal. Thanks again for flying in from Rochester. Certainly appreciate it.

SCORSE: You're welcome.

ROSS-NAZZAL: Tell us how you became involved with the James Webb Space Telescope.

SCORSE: I worked on Chandra, the NASA Chandra mission, and at that time I was a contractor, worked for Eastman Kodak Company. When that mission [launched] there wasn't an immediate follow-on, so I went back into the Kodak engineering area. I worked there for I think about three or four years. My former supervisor from Chandra called me one day and said they had just gotten involved with—at the time it was the Next Generation Space Telescope, which would become James Webb.

He said, "You interested in another telescope?" …

I said, "Absolutely."

He laid out the architecture and told me what the proposal looked like and what was entailed in it. It sounded interesting. That was in 2001.

Late 2002 I moved from the area of Kodak I was in in the engineering area back into government systems, which handled these contracts. It was me and one other engineer, [we] were the first two engineers on the job in late 2002. Over the next two or three years, we added several key people, pretty much just starting to come up with concepts for the test arrangements. There were still trades going on to where the test was going to happen. They looked at [NASA] Plum Brook [Station, Space Power Facility, Sandusky, Ohio], which was [NASA] John [H.] Glenn [Research] Center up near Cleveland [Ohio], and they were looking here. They did look very briefly at Huntsville [Alabama, NASA Marshall Space Flight Center], but the chambers weren't big enough. We were in a downselect on some architecture we did between the two sites.

NASA ended up deciding to come here to Johnson Space Center, I think largely because of the total infrastructure and their history with Hubble. The architecture took a shift toward making it work here. There were several trades deciding how we were exactly going to use Chamber A down in Building 32 to create a cryo vac [cryogenic vacuum] test, and then we [had] another trade study and [came] up with a cost-to-benefit solution. Then we proceeded into the design efforts.

ROSS-NAZZAL: I wonder if you can walk us through, because so many people are thinking test, they're just thinking about the time that OTIS [Optical Telescope element/Integrated Science instrument module] spent over in the SESL [Space Environment Simulation Laboratory]. They're not thinking it took so many years to come up with this. [I] wonder if you can talk about when you first started in 2002. How did you come up with the ideas for how you might test this equipment, this hardware? How did you start from scratch and move forward?

SCORSE: There's a list of optical and performance requirements the telescope had, just from the telescope design. Every one of those performance requirements needed to get verified one way or another. They either do it by analysis or by test or by inspection. The test sequence was test at temperature, which for this telescope is minus 420 degrees F [Fahrenheit]. It's hard to even get your head around what that really is. That created an environment we had to stay within.

Then the telescope itself, by its optical prescriptions, created the distance at which optical equipment could actually do this verification. When you put the telescope on paper with this optical equipment you come up with a distance, and that distance is how much free space you need just so equipment like an interferometer can even look at the primary mirror and make sense of whether or not you met the prescription requirements.

From there you'd move into the infrastructure you would need around all this equipment to even make this equipment work in a vacuum at those temperatures. Then you look at the infrastructure below the telescope to try to understand what it would take to actually create a nest or a way of supporting the telescope in a way that you weren't inducing errors into the telescope. You'd build this whole package together. You look at how big it is. You look at the chamber. Then you pass this information on to the folks here at Johnson.

We worked with them very closely to re-create, so to speak, the inside of the chamber and the environment it needed. There were tons and tons of mechanical interfaces required, changes in their thermal systems to meet the requirements. We worked from 2005 to probably, I think, 2010. In that timeframe we pretty much had the architecture ironed out really well. We were at some critical design reviews already.

I think from roughly 2010 to 2013 we were in the building years of actually [constructing] the hardware. Johnson was busy retrofitting the chamber and building a clean room and all the other site work that needed to get done. Lots of work getting done. Some of the structures we built to go in there to hold the telescope and the test equipment we had to build here on site because it was so big. [We] couldn't bring it across roads.

Every piece of equipment that was built had to have its own verification testing done on it. Whether it was load testing or its functionalities, it had to be tested just to put it into service. So there was a tremendous amount of engineering and testing. These tests are very formal. You create a test. You write a test plan and a test procedure, and you conduct the test. If there's anything that doesn't meet it, it's a failure. You go back, and you correct it and retest. We were lucky. … Everything went very well.

ROSS-NAZZAL: Can you talk about some of that optical test hardware? I've talked with [Jonathan L.] Homan about the changes to the chamber itself here at JSC. But I wonder if you would talk about your side, because obviously you were working more on the optics.

SCORSE: There was several pieces of optical equipment. It was a combination thermal and optical test on the telescope. It's interesting, because as the program evolved, its thermal side became much bigger than I think anyone ever expected, or at least anything that ever appeared to be the scope originally. It became an incredibly complex [situation] to control the temperatures in this telescope.

The optical equipment, we had a center of curvature system, which is a custom-made interferometer having the ability to look at segmented mirrors, 18 segmented mirrors at a single time, and bring them into a single picture. We had a photogrammetry system; we had four photogrammetry cameras in the [chamber] at temperature in vessels so they would stay at ambient temperatures and pressures. We constantly took pictures of the telescope and the surrounding area so that we could monitor changes in the telescope down to less than 100 microns, I believe, during the cooldown and the warm-up.

We had three very large mirrors, meter-and-a-half size mirrors, in there. It was bouncing light through the telescope into the science instruments so they could do the verification on the science instruments through the actual telescope.

There was a significant amount of optical equipment that took a lot of time to develop. The large meter-and-a-half mirrors that were in the top of the chamber, we built those in Rochester. We had our own cryochamber in Rochester [where we performed the testing]. The [mirrors] were figured for that temperature. They would look distorted at ambient temperature, but at cold temperatures they looked very good.

There were [many] companies [from across the U.S. that contributed to this program]. … For the interferometer we reached out to 4D and PhaseCam in Tucson, Arizona. They specialize in phase-shifting interferometers. We had put an isolation system in the chamber, and we went to a company called Minus K in California that specialized in mechanical isolation as opposed to pneumatics. There's another company in Tucson, Arizona, that fused the large mirrors that were in the top of the chamber for us. They had a process for fusing borosilicate, which was a favorable material for the temperatures we were going to be testing the telescope.

Johns Hopkins University [Baltimore, Maryland] had a division that worked with us to build the photogrammetry system. We created an architecture and a plan for how we wanted to use these, and they did the engineering for us and some of the early testing. They employed a manufacturing group in Baltimore, also here in Houston. It's called Oceaneering. [They] did some of the fabrications and the early assemblies for us.

In that 2010-2014 period, there was a tremendous amount of fabricating, testing, contracts, subcontracts being managed and led. That was a big growth period in the program overall.

ROSS-NAZZAL: You mentioned that some of those structures were so big they couldn't actually go on a road. Can you talk about some of those structures that were built here?

SCORSE: Yes. There were two of them. … One of them was nicknamed the HOSS. It was an acronym for Hardpoint/Offloader Support Structure. It's a massive weldment. It's [approximately] 32 feet long [by] 22 feet wide. If you sat it on the floor it stands [approximately] 8 feet tall. It looks somewhat like an oblong dish. It was built so that we could support the telescope on it and still suspend it from the top of the chamber.

The interesting thing I didn't mention was the isolation system in this chamber was a suspension system, so that the entire test arrangement, including the telescope, was hung from the top of the chamber. It was somewhat like a marionette, but it was isolated, so you could keep it quiet. That way we could control the disturbances that went into the system.

We needed something that once we had the telescope on it we could lift up and hang. The telescope was 10,000 pounds. I [believe] we had a 60,000-pound limit on the chamber. All the other equipment and the telescope had to stay in that 59,000-to-60,000-pound range, so it was another requirement. It had to be balanced. We had to have a center of gravity that would allow it to be balanced correctly. It was another requirement to work into the mix.

ROSS-NAZZAL: I understand that originally the telescope was supposed to be facedown, called cup-down, and then it became cup-up. Did that create any problems for you guys working on that optical equipment?

SCORSE: It was [a challenge].

ROSS-NAZZAL: How so?

SCORSE: Originally, we would put the telescope together at [NASA] Goddard Space Flight Center [Greenbelt, Maryland]. It would come here [to Houston], we would do a cryo test on just the telescope without the science instruments to make sure the telescope met verification. Then it would go back. Then it was going to stay here, and we were going to bring the science instruments here to install them. As that developed over the years of understanding what that meant, there was just way too much infrastructure required to put the science instruments on the telescope. You couldn't bring enough equipment here. The clean room wasn't big enough. The space didn't allow for it.

As you said there was what they called the cup-down orientation. If it was cup-down, the telescope would have had to be tested in the top of the chamber. That would have created [a challenge] trying to get it in and then get it all the way up and then get all the test equipment in the bottom. It would have literally taken our test arrangement and turned it over. The idea was if we kept it facing down, it would stay clean. The cost and the complications of doing that were lost in another trade study—the practicality of it. There were other methods to maintain it that they decided to employ.

ROSS-NAZZAL: You mentioned cost. I imagine being in your shoes that's always an issue. How did you find you were able to balance cost and schedule but also maintain a safe work environment for your employees while working on all this?

SCORSE: There was cost growth. … I think they decided to build a very good telescope and a very difficult telescope. I don't think in 2000 they really understood, and I don't know how they could have understood, all the nuances that they were going to experience over the next 10 or 12 years before the telescope got here.

There was growth. A lot of growth was due to the engineering studies that were done that said that the early modeling of the telescope and the performance structurally and thermally and optically were not as detailed. As the generations of modeling continued, they got more and more detailed and when they did see a small problem with a model it took even more and more detail to solve it, which eventually evolved into more requirements. More requirements were passed to everyone, not just to Harris—[Kodak at the time, now part of L3Harris]—but to Northrop Grumman, Ball [Aerospace], everybody.

We continued to refine it but also try to create creative ways to address the [additional requirements] without it costing any more than it did. … You had to be extremely vigilant. I had up to nearly the equivalent of 120 to 130 full-time people on it at times. You really have to stay involved. … The more eyes you have on something, the better. It's a delicate balance between not micromanaging somebody, but at least understanding that they're covering the details well.

It becomes sometimes what's the goal: the cost, the schedule, the performance. Generally, it's schedule and performance. If the schedule starts to be a threat, it's usually man-hours that keep it under control. We were lucky when we worked down here [in Houston]. We were here five years. We worked down here. We had a very captive audience down here, because we were here from Rochester. We weren't going home. …

It [was] easy to get people to work and keep people working. People were eager to work. They were down here. We [had] a tremendous group of people that were very interested in this work and their jobs, especially when they get hardware in their hands. It's really a nice environment to be around people that want to pull forward. I was really lucky in that respect.

ROSS-NAZZAL: You didn't feel like you had to motivate people very much.

SCORSE: Not really. It wasn't hard to motivate people at all. We had a rotation here. I think we had about 60 people in rotation. Some of us were here more than others, obviously. Some people rotated in and out at two- and three-week intervals. Some people came in for just the time they needed. When there was a test, the test engineers were here for the duration. I think the longest test was the last test; it was 100 days. It was a long test.

Thermal guys were in the unique position that they helped put the telescope together because they needed the thermal equipment, blanketing, diodes and all the telemetry [equipment] to be just right. They would be here when we put the telescope together. The minute the test started they went to the control room, and they were part of the test. They didn't get much of a break for a few years but did a phenomenal job, phenomenal job.

ROSS-NAZZAL: It's my understanding that there were a number of review boards as you guys were coming up with these test plans. Can you talk about what impact that had on the designs that you had come up with and the type of hardware you decided to build?

SCORSE: A lot of those were the design trades. There were several of them. Somebody would identify an issue, whether it was cost, schedule, or technical, and they would identify maybe two or three options you'd have to go off and work. Then you'd have to bring them back and they'd make a downselect based on what are the gives and takes of each one and what [are the] schedule, cost, technical impacts. They would move forward with something. There were several of those.

I didn't sit on as much as I did the mechanical stuff, but there were several around the science and the test of the telescope as to how to test it, what you're going to get from the test. Some of my test engineers like Conrad [Wells] or Tony [L.] Whitman or the folks from Ball and Goddard [were] a big part of those [tests]. …

ROSS-NAZZAL: What is your background? You said you were working in Kodak engineering before you got pulled to work on this project.

SCORSE: I'm a mechanical engineer. I worked at Kodak. I started there in 1979.

ROSS-NAZZAL: Oh, wow! You've been there a while.

SCORSE: It's a long time ago. Actually, in January it'll be 40 years. [ITT (International Telephone and Telegraph) acquired the Remote Sensing Solutions division of] Kodak. [Eventually, we became] Exelis. Harris [acquired Exelis in 2015. (L3 and Harris merged in 2019.)] The division hasn't changed over all these years. I've been really lucky. …

I worked in several areas at Kodak engineering. I was in facilities. I was in some machine design. I worked in government systems as I said earlier on Chandra. Kodak was so large at the time. There [were about] 90,000 people working there at Rochester. There were several film divisions. There was the camera division. There was the 35-millimeter (movie film) [area]. They had their own synthetic chemical areas. There were so many areas, there was so much engineering there. There was process engineering, there was equipment engineering, facilities engineering.

Depending on how the wind blew, from '79 until we were spun off was the period of time when Kodak was starting [having issues]. A lot of the big companies were. We shifted around to a few different jobs. [I] had a lot of experience with a variety of engineering across the scope of mechanical work. [Things slowed down in the] early '90s. When I went [to work] on the Chandra Program, they had an opening in government systems. They were looking for a mechanical engineer. I started working for Gary [W.] Matthews. I don't know if you talked to Gary.

ROSS-NAZZAL: We did, yes. He was the first person I talked to.

SCORSE: I worked for Gary Matthews and bounced around between Rochester and Huntsville and LA on that program. As I said when that was completed there wasn't an immediate follow-on. I went back to Kodak and did some more research engineering for a few years. Then I started on this program as I mentioned in '02 as an engineer and then as the program developed and we added more people I became an IPT [Integrated Product Team engineer] and a deputy and [finally] a program manager. I've been a program manager since 2010.

ROSS-NAZZAL: You get to do all the fun stuff.

SCORSE: I got to finish the design and do the builds and the test. It's been a career in itself from 2000 to 2018; it's a career in itself almost.

ROSS-NAZZAL: I had asked Conrad but I'm curious, you might have a different take. Being a contractor, I know, you change your badge. You're lucky your pension is rolled over. We always have to change our retirement and health care. Did that have any impact on the test and design? You're working with different companies; they have different cultures, different attitudes.

SCORSE: No, I think because they moved us as a division the culture stayed pretty much intact. The thing we did notice, at least I did, I don't think the engineers felt this. When we went to ITT and Exelis, we were publicly held companies. Kodak was too, but Kodak was very big. It was kind of a how big of a fish are you in the ocean. With Exelis we became extremely small, so the program was actually a major part of their performance predictions to stockholders on Wall

Street, so there was quite a bit of pressure I felt then for performance predictions, which in this business can get pretty hard. You've got your government fiscal year you got to work with. It is what it is. There's no more, there's no less, and there can always be less. There can always be a change where they're going to reduce something. You feel that kind of pressure.

Over the period of this program I've noticed that program management, project management, the focus on cost is getting much more attention than it ever did. I think there's some good to it, and I think in other cases it creates a lot more metrics that take more time to do. It really doesn't change any decision you can make or anything that can really impact what's happening. It's the way things are going.

I have three sons. All three of them are engineers. All three of them have their master's degree. They have really good jobs. One works for GE [General Electric] Aviation. One works for L3 [Global Communication Solutions]. They do small satellites. He used to work for Boeing. Another one works for a company in Wisconsin called Epic, which is a large medical software company. They're all low-level managers right now, but they feel the same thing. Engineers go to school. … "Just let me get this done. You'll be happy." You're not really schooled in that. What I've learned is there's a business of engineering. …

ROSS-NAZZAL: That is true.

SCORSE: Or else they don't need you.

ROSS-NAZZAL: That's the sad part. You mentioned all of these different companies across the United States. Of course JSC was involved, Goddard was involved. My understanding is that

JPL [Jet Propulsion Laboratory, Pasadena, California] was involved a little bit. Wondering if you can talk about working with these various companies and Centers and maybe some of the challenges associated with that?

SCORSE: They've all been very positive. We did work at Marshall Space Flight Center. We did testing down there. I worked there with those folks on Chandra, and they're wonderful people, very helpful. Goddard, again, they were extremely focused on the technical and the health of the telescope. They certainly did not neglect cost and schedule by any means. They were a very cohesive group there, and they were personally involved in the telescope. Northrop Grumman used to be TRW and most of the players there were part of the TRW Chandra team, so I knew those folks. They again [were] very involved in the telescope.

It was a very common interest type thing. It's like anything else where you get people in a room, and they all got a common interest about one thing. So, it was very positive.

Johnson, we've had incredibly good experiences down here. The larger shops built some of our larger equipment, very knowledgeable people. Their chamber vacuum people that retrofitted the chamber, I think they did a wonderful job on that chamber down there. Easy to work with.

I think the thing I've learned working off site on any job is you've got to understand how the folks on that site have to work, because you got to work within their system. Harris has our rules. We're contracted to Goddard. Goddard has their rules, and Johnson has their rules. You bend to the one that's the most stringent so you satisfy everything. We had things to learn when we got down here. There were protocols that we had to learn. Different here than other NASA places because of manned space, [it] has a big impact on all their processes here, so that they're somewhat different than a Center that just does optical work for instance. Their chamber protocols are a little different. In the end they're all after the same thing, but they do have special things they observe that may not be done somewhere else.

We were here much more and much longer than we anticipated. Originally we were going to be here for three pathfinder tests and then the telescope test. It was envisioned early on that we would come down here, put all of our equipment in the chamber in about four months, and then we would test the pathfinder telescope for a month. We'd go away. They'd think about the results, and then they'd get ready for the next pathfinder test. We'd come down and put that pathfinder in and test that for a couple months and go away. It turned out we came down here in late 2013, and we just left in June [2018]. …

ROSS-NAZZAL: What accounts for that? Why do you think people thought, "Oh, this is just going to be so quick," and it turned out to be much different?

SCORSE: That was the proposal days back in 2000, what I was just speaking to. As the program matured they realized that when we put all this infrastructure in the chamber, we've got to do a cold load test to make sure the structure itself is going to survive the cold, before we go putting a telescope on it. There was an extra test there.

For a cleanliness thing there was a chamber bakeout test. I think prior to us getting here they had to have a cold test, just to make sure the system would get cold. As they started to decide what each one of these pathfinder tests were going to achieve, what were they going to learn, and what requirements were they going to satisfy with them, the list started to grow. "As long as we're there we need to know this, or we need to know that," or something else.

It just evolved. It was like a mushroom, it just kept [growing]. The second pathfinder test was to actually bring the optical system of the telescope down through the Aft Optical System and actually put light through it, so they needed a detector to catch the light. They had a Beam Image Analyzer built—I think it was a six-axis stage so that they could do that, but it was something that we never had in our plan to install. We had to do some modifications to HOSS to actually get it in place under the pathfinder telescope actually to do that.

All that just takes a little more time. We got to thermal pathfinder. I think we put 1,800 sensors on the test structure and the pathfinder telescope to monitor thermal temperatures. It was tremendous. Every one of them had to be put down, taped, a wire run to a connector to a lead, to a pigtail, out the back of the chamber. When we got done with the test every one of them had to be disconnected and removed. It was that kind of thing. The getting ready, the test, the deintegration if you want to call it that, and then get prepped for the next one.

ROSS-NAZZAL: You said something that I thought was interesting, and that was that working here was a little bit different than working at other facilities, especially NASA facilities, because of human spaceflight. [I] wonder if you can give an example of working over in Chamber A and how that was different than say working over at Marshall or Goddard.

SCORSE: I can't think of it at the moment. Let me come back to it.

ROSS-NAZZAL: That's okay. Think about it. That happens to me a lot. Somebody'll ask me a question, and I'll think about it. Of course then I leave and I think about it. We can always add it later too.

SCORSE: All their protocols on their chambers are for manned flight. Having a person in a chamber is a big deal. It's a big deal. I think it was just making sure we complied, understood that there was a difference. We got to the point that it was pretty seamless, but there were differences. There were differences, but like I said I can't pull them off the top of my head right now.

ROSS-NAZZAL: You of course shared with me that you worked on Chandra. I'm wondering how your work on Chandra influenced your work here with the Jim Webb Space Telescope and also the optical hardware.

SCORSE: That's an interesting question. When I came on Chandra they had several pathfinder tests with Chandra. They had just had a few, and they had [some concerns] with the early ground support equipment. My job was basically to get every piece of equipment that had a problem and fix it. Redesign it, rebuild it, redo it, if I could redo it. I ended up rebuilding a lot of stuff. I built a lot of new stuff. I also built some of the equipment for the actual prime telescope.

We had a system in one of our clean rooms where we had to support the prime telescope. I developed an offloader system to hold the telescope while they were integrating the mirrors for that. My takeaway from Chandra was again the details. The details of understanding what the equipment has got to do and how do you want to make sure it's going to work.

Equipment has to work. It's like anything you buy. You buy an iPhone. It has to work. You don't buy an iPhone expecting, "Well, maybe it won't work." You buy an iPhone because you want it to work. That's the way the stuff should be. So, you have to hammer it yourself a little bit to make sure you really understand what you want this equipment to do and can it really do what you want it to do.

There's a thousand ways you do that. It's drawings. Are your parts being ordered correctly? Did you spec [specify] the right parts? Are receiving inspections being done correctly? There are a million things that you have to do. That's why when I said earlier I don't like to micromanage, but I do like to stay in the details. I see people get working fast, and you find something that doesn't go together and come out of a CAD [computer-aided drawing] system and everybody stands around going, "Well, how does that happen? It was in a 3-D CAD model. It had to work."

You look at the drawings that were given to the machinist. "Well, there's a typo error there and something else there." If the machinist built it just to your drawings it's not going to go together. Human error is still there. A planner looks at a material list and types the numbers in and switches two numbers. You get a different part. Screws have a bunch of numbers. You get a couple numbers switched, and you get a different part. Then all of a sudden you're on the floor working, and something doesn't fit. That's what I took way from Chandra.

ROSS-NAZZAL: Do you feel like Hubble had any impact on designing the hardware and the tests that you came up with? Was that constantly following you around?

SCORSE: Hubble was mentioned a lot by Goddard. … It was the verification. We did a lot of subscale testing. Things we called risk reduction testing, where you would test small components as a part instead of waiting till you had something very large and expensive. Or you would test something early to make sure it was going to work. If you needed to make a change you could see some reality. As good as all the math modeling is, sometimes the reality of the hardware is totally different, or a little different, just enough different that it causes you a problem.

There was a tremendous amount of that. I think that was really good for the program. Many times when you get to these larger tests, you have one shot at it. My son works for GE Aviation, and I talked to a manager down there a few years ago when I was down visiting and touring. They told me when they bring a new engine online in service for an aircraft they may have 12 of those they've built. They build one, they test it, they find out what's not right about it, they build another one, fix that. They invest. It's a sum cost. They invest in 12 of them before the FAA [Federal Aviation Administration] certifies one to actually put on an airplane and put people in it.

With a James Webb, you got one telescope. You got one cryo test. There's no going back and building two more, three more, getting it right. I think the angst that Hubble may have saved. Maybe it's because of this thinking now that you do more subscale testing. You understand stuff better before you put it into larger systems.

If you don't have the money to do prototypes, so to speak, then subscale testing and risk reduction testing I think is a real benefit. Some of that was born with the Hubble experience they had. I give Goddard a lot of credit for doing that kind of risk reduction testing. You learn a lot.

ROSS-NAZZAL: I'm sure you guys did.

SCORSE: [When] we did thermal pathfinder here I think it really opened a lot of eyes as to what the thermal system was really like and just how much attention to detail it took.

Everybody knows when something gets cold it gets smaller. When we put this large telescope with large space simulators and all this stuff together, before we put it in the chamber we had to go around. I think we made over 1,000 measurements of gaps that we had to monitor so they didn't collide or they didn't impact some function with the test that would throw the test. One of my guys has a spreadsheet, and I know there's over 1,000 lines on it of all the gaps and all the interferences and things that we had to monitor. It's just staggering. It was staggering, just the attention [to detail].

You're working with something that's 10,000 pounds and 25 feet long. You have to set it and the things next to that—you can't have a gap that's larger than something, or you have a problem. It was the same with tensioning blankets and all kinds of things. Nothing could be done haphazard. Everything had to be thought out.

ROSS-NAZZAL: Yes, it sounds like there was quite a bit of detail in everything. I know Conrad was telling me about the details he had to provide.

SCORSE: Yes, the details.

ROSS-NAZZAL: It's just astounding to me, not being an engineer myself.

SCORSE: It is. It is.

ROSS-NAZZAL: You talked about coming down here and having a captive audience because you're here to work. What were your hours like when you would come down and work?

SCORSE: Our base hours were six days, 10-hour days. Typically we'd work that. We did work a few weekends straight through where we needed. We did work some 11- and 12-hour days once in a while. I typically worked a little more than that just because I had to get ahead of everybody in the morning and clean up a little bit when they left. I had work to pay attention to here, but I also had my own business reports and other things to do. That stuff didn't go away. I worked usually half days on Sundays. Most of the guys had Sundays off. They'd sleep in, they'd do their laundry. It was pretty much just get ready to go back to work Monday.

ROSS-NAZZAL: When you started coming down here in 2010 what were your rotations like? How long would you stay down here?

SCORSE: In 2010, we were only coming down for meetings. We didn't really deploy down here till late '13. That's when those kind of hours kicked in.

Then it depended. Everybody had a little bit of a different rotation depending on their family life or demands back in Rochester. Some guys, once we got through design phases, moved to other programs so that when their hardware went into the chamber they'd come down for a month or something and then they'd go home. Other guys were more support that were on constant rotations.

I did like three weeks down one week back for a long time. Then there was a period I went to like two and two. Then when we just finished here, I think I was down here like four, five months straight almost this last go-round. It was a long time. I went home a couple weekends. I'd fly home late Friday and fly back Monday morning sometimes, but you'd spend so much time in airports.

ROSS-NAZZAL: I was just thinking that. You mentioned you can't just directly fly from Rochester to Houston.

SCORSE: No, it's two planes each way. When we were getting done down here, there was so much heavy work getting done, I just felt I needed to be here just for safety.

The optical system we had in the top of the chamber that had the large mirrors and the center of curvature system on it, we had to bring that down on three separate cranes. That thing weighed almost 20,000 pounds. I wanted that to come down really slow. Didn't want anybody hurt. We had some disassembly to do just as it got to the bottom. We had some disassembly to do while it was still not quite set on its cart. It was just things like that.

There were things that we put together. As I mentioned there was a suspension system. The top and the bottom was hung by titanium rods. There was a lot of joints, and those joints were put together and they sat there through I think six cryo cycles over a period of five years. It was questionable if they were going to come apart just because of the load on them and with the vacuum, whether or not the greases had migrated away, and whether or not we'd just get them apart.

Potentially you could have had hourly issues. As it was, we didn't have any, but there was a lot of reasons that I felt I needed to be here.

ROSS-NAZZAL: How did you get your hardware down here? Were you trucking it down? Were you flying it down?

SCORSE: Trucking it, yes. Actually when we left we just pulled it all out of here. I think we used, I've heard two stories, 16 and 20 40-footers, tractor trailers, to get it out of here. Then the big pieces are still sitting over there. A lot of stuff.

ROSS-NAZZAL: That is a lot more stuff than I realized.

SCORSE: Oh, yes, it's a lot of stuff. It's a lot of stuff. God, I think we had 100 miles of cables in that chamber.

ROSS-NAZZAL: A hundred miles of cables.

SCORSE: Yes.

ROSS-NAZZAL: Jonathan was telling me about the importance of keeping it sealed and keeping those temperatures. With all of that wiring, how do you actually keep something sealed up tight to maintain that 40 Kelvin temperature? Normally when you put a wire through something there's got to be a hole. So how do you ensure there's not a leak?

SCORSE: There are connectors that they put on chambers that they're sealed. But the interesting thing is the cable is a huge thermal conductor. They have vacuum connectors, so the vacuum connector part is easy. The hard part or the tedious part was the thermals. We had to build in the back of the chamber—if you go in there it's still there—there's two shrouds. There's a helium shroud and an LN2 [liquid] nitrogen shroud.

Behind those shrouds we have aluminum shelving we built to actually run these cables on as conductors so the aluminum would conduct. They were foil-wrapped with thermal tapes to the shelves so that over the length that they traveled inside the helium shroud they would not be conducting any heat in.

As I said there's like 100 miles of cables we took out of there and put in there. We have pictures of them. I can't even describe the pictures to you. You'd have to see them. It's just like bookshelves of white cables. They have these things they call towel bars. When they had to jump to the next shroud you'd have a rod, and they'd just all be running across it like a waterfall. The cables had to be engineered.

You had a thermal engineer working on how we're going to handle these cables in there. Then we had a dynamics engineer working on how we actually created the loops, splayed them out, so that they wouldn't disturb the telescope while they were plugged in.

ROSS-NAZZAL: Things that you don't think about.

SCORSE: Because the first test we did we found that—they weren't splayed out and looped, we thought if we just draped them to the floor it'd be enough. But it was picking up the small motions off the floor. The floor like this was enough to disrupt the test.

ROSS-NAZZAL: All sorts of things that you learn.

SCORSE: Yes.

ROSS-NAZZAL: I did want to ask you about those tests. You had the OGSE [Optical Ground Support Equipment]-1 and 2. What was your role during those tests?

SCORSE: I mentioned Tony Whitman. Tony Whitman was my chief test engineer. When we were down here and I was orchestrating and managing getting hardware put in, Tony was working with Goddard to develop the test plans, test procedures. Then he would work with Goddard and Ball and the rest of the team to run the test.

We kind of had swapping roles. Once we were ready with the test and then we had the test article in the chamber, I would go home. Tony would run the test. While we were home, we already knew a lot about what we had to do for the next test. There was engineering and design work that needed to get done. I'd go home and push that, get those things ready to go, so that when the test was over we could ship the next bunch of stuff down.

That was kind of the way it worked. We never got to a point where there was nothing to do. You were always getting ready for the next test and every test built off itself. I think the test schedule held pretty well. Last-minute developments was a little bit of a hustle to get something changed to correct it for the next one.

ROSS-NAZZAL: I was wondering if you would talk about that. Were there things that you had to do on the fly during these tests? All of a sudden something flared up, and we need X?

SCORSE: There were a few. The thermal pathfinder stuff was interesting. The thermal engineers had a very good grasp on what they needed. When it came time to actually implement it it was a much bigger effort than what any of us had thought of or put in the schedule. So those guys worked; they worked hard trying to get that thing ready.

When they brought the Beam Image Analyzer down for OGSE-2, there was some fit issues we had to correct. There were actually some fit issues when the telescope got here with some infrastructure also. The telescope envelope had grown a little bit over the years and hadn't allowed for where some of the GSE was. We had to make some accommodations there.

We had some leaks in the early testing we had to go correct before we got to the second test. We had, as I mentioned, the center of curvature system at the top of the chamber. The actual interferometer was in a vessel that was kept at 70 degrees, an ambient temperature and pressure, and it was vented through the top of the chamber. So we did have some leaks up there that did affect the chamber performance we had to correct.

After OGSE-2, they decided they needed more thermal control on the large ACF [Auto-Collimating Flats] mirrors that were in the top of the chamber. We had to build an entirely new thermal system to add to those mirrors, so we actually had to retrofit in place thermal cooling plates and extra blanketing on these mirrors that were like 80 feet in the air. We had mass restriction to deal with. We did accomplish it. We suspended like a pie plate over the top of them that had direct helium cooling that was suspended from above it, so it wasn't actually sitting on the mirror itself, it wasn't on the glass, it would just radiate to the mirror.

Then we had heaters on it, and we had heaters around it so that as it got cold we could tweak the heaters and actually bring the mirror closer to what was optimum for the test. That was probably one of our bigger rushes, because you only had so many days to come up with the design, get the hardware built, get it down there, get it put in. That's the kind of thing. …

ROSS-NAZZAL: How well did your optical hardware work during the test phase, those three tests that you did?

SCORSE: I think I can say with a lot of confidence that it worked really well. We met everything. I think we exceeded in many cases things. If you talked to Lee [D.] Feinberg or Conrad Wells or Ritva [A.] Keski-Kuha I think they would say that we probably had a better optical test than anybody would have ever expected you could do with those temperatures and that amount of complicated hardware in a chamber.

It was a phenomenal test, it really was. … The test itself, the hardware, ran so good, it was really incredible. I think everybody wondered with a 100-day test, being that cold that long, trying to keep the chamber cold that long, throwing [Hurricane] Harvey on it.

Harvey was pretty serious. We almost lost LN2 supply, which would have shut that test right down. The amount of electronics that were in there that were collecting telemetry—as I mentioned, the heart of the test was this 4D PhaseCam interferometer. It was buried inside the chamber inside a vessel. We had redundancies in there. Had something went wrong, it was definitely a single string failure kind of a thing. After you got through your redundancies, you were done.

A lot of the hardware that we had, the GSE, the ground support [equipment], the stuff was designed in '08 and 2010, and it was built shortly after. So by the time you get to 2017, you've got laptops that are seven years old that you're running stuff on. Some of the stuff, the drivers with the electronics and the cabinets, you couldn't swap them out. We had spares. Luckily we had older spares of stuff. That's the trouble with older programs. As programs get older, especially with electronics and computing, the generations change so fast. Everything worked.

ROSS-NAZZAL: I think Gary mentioned that you guys were still using [Microsoft Windows] XP that's been out of service for how many years. I don't know. You found a supplier that provided motherboards and other things that you needed.

SCORSE: Yes, it was wonderful. It was a wonderful test. It really was.

ROSS-NAZZAL: You mentioned in between the testing you would go back up and get hardware ready. What was your role during the actual 100-day test? What were you doing?

SCORSE: I was still responsible for our whole program with our company. I was responsible for the test guys and the engineers and the guys getting ready for the next one. It was very similar to what I would do down here. I had my typical monthly cost management stuff with the company. I had the same stuff with the customer, with Goddard.

We got an integrated schedule across all the IPTs, so there was activities between tests. One of the big activities was we had to write manufacturing instructions for everything we did in high detail. Let's say you're in the middle of OGSE-1. When you get done with OGSE-1 you take it out of the chamber, take it apart, and disposition everything someway. You need paperwork to do that. You need a document that says, "Take it out of the chamber. Take these bolts off. Take these bolts off. It's all signed off by QA [quality assurance]." You've got engineers sweating over drawings, writing all these instructions up, so that that work can happen as soon as the test is over. That was one block of work that was getting done.

The next block of work was when you move from OGSE-1 to OGSE-2 to OGSE-3 there were phases of the ground support equipment that actually went in the chamber. It didn't all go in initially. Initially we just put the structural system in, did a cold load test, and then we put OGSE-1 in. Then we kept adding equipment. I think during OGSE-1 we were starting to build some of the thermal simulators that would go in for thermal pathfinder.

We continued building these deep space radiators that we had to surround the telescope with that were going to be used for thermal pathfinder. Those were under design and build. Then there was additional infrastructure to hold some of this stuff in the chamber. I was going back and forth. Even when I was down here working on OGSE-1 I was keeping tabs on that. It was a flip-flop. There was no break. Trying to do some of this stuff over a distance is hard.

ROSS-NAZZAL: When the test started in 2017 would you come down on a regular basis? What was your role then?

SCORSE: No. Actually when the test started I went back, and we just worked on the final set of paper. At that point I had started releasing people from the program. I kept the manufacturing engineers. They started working the paperwork to get it out of the chamber and close it down. There was a lot of work we had to do to actually take all the equipment out of the chamber.

There was paperwork that had to get done. There were systems that had not been used in five years. We had to go back and see if they still worked. We had to get ready with load test plans and things like that, because the lifting equipment hadn't been used since we put the stuff in. It was a whole raft of things we had to get organized and restart to do. It was not a quiet time; we were busy while they were down here testing.

When the door opened it was like you were expected to be there with everything you needed to start work. That's the kind of things we were doing. Then when the test did finish, I think when the door opened we didn't get at it right away. We spent a month. They were trying to redo a couple anomalies they thought they saw, so we helped. We worked on that for a month before we actually got started taking the telescope out.

ROSS-NAZZAL: How many people did you have working down here during the test for Harris?

SCORSE: During the test? I'm going to say 15 actually on the test here. Probably had another half dozen dynamics engineers, optical engineers back in Rochester for support, and probably had another 10 or a dozen engineers working to get ready for the next phase. Then I had a program office, I got a finance person and a scheduling person and a business person.

ROSS-NAZZAL: Everything it takes to make the organization operate. Were there any major challenges that you had to face when the test was ongoing? Obviously you mentioned Harvey. Harvey was kind of a big deal.

SCORSE: Harvey was probably the toughest because we didn't know where it was going. The [hurricane] got here and it parked. Do you live here?

ROSS-NAZZAL: I do actually. Yes, I live right outside the gates.

SCORSE: So you were here.

ROSS-NAZZAL: Yes.

SCORSE: They were sending me pictures. They were using 30-gallon garbage cans as rain gauges. When one would fill up they'd put another one out next to it. They ended up with 55 inches. Just like a tape measure, they're measuring. I had guys run to [a store]; they bought 25 air mattresses. … We were concerned. The test was going to be safe if all these things didn't happen. You started looking on a regular basis. There were meetings after meeting after meeting as to how you manage the people going back and forth, as you heard, and how they're getting fed, getting sleep, when's the storm going to end, what's the storm going to do next.

My management in Rochester, of course, was concerned about our people down here. So hourly I'm getting e-mails or phone calls from a different manager from one place or another asking me, "What's the status? Who's who? How many people are there? Who are the people? How long have they been there? How much sleep?" All this human relations kind of stuff was going on.

Our parent company, Harris, is in Melbourne, Florida, so they're very familiar with hurricanes. They've got hurricane protocols, so their hurricane people were calling me all the time.

ROSS-NAZZAL: You got no rest.

SCORSE: I'm trying to get ahold of guys down here, and phones aren't working. They were lucky. The site was in the right place, I think. They were really lucky. Then some of them went out and helped do some aid work right after it ended.

ROSS-NAZZAL: Yes, I understand that was a big push.

SCORSE: Which was nice.

ROSS-NAZZAL: Did your company send a plane? I understand some of the companies chartered planes.

SCORSE: I had a plane lined up to bring some people down. About the time it was going to become available we got a commercial airline, so we canceled it. Yes, they were working with Ellington [Field, Houston, Texas] to bring a plane in, because we had people here so long.

ROSS-NAZZAL: I'm sure people were exhausted and ready to come home and get some relief.

SCORSE: Yes, it got to be hard. Every time you looked outside it was just raining. …

I told Goddard early on, I said the biggest threat down here was water. It's just water. Whether the roof leaks, whether you lose a pipe, whether you do anything, you have so much electronics outside the chamber that water is the thing that will kill you the quickest. Luckily, over the years, there was enough provisions put in. They had shielding over the top of some of the cabinets. Some of them they put curtains around. They survived it. It was just luck.

Could you test that telescope again for that many days with that storm and come out the same? I don't know. I don't want to find out. I'd just as soon sit on this success.

ROSS-NAZZAL: Luckily everything went well. That's good. Have you been back since the test was done? Obviously you're here today.

SCORSE: I left in June. June 15th I left here. I think just before the last truck left I left. This is my first trip back.

ROSS-NAZZAL: I imagine the SESL looks a little bit different without all your hardware.

SCORSE: Yes. Things feel different. I thought about driving down to [Building] 32 when I leave here and just seeing what's going on down there. We are interested, if they do more work in that chamber, if they need any kind of work similar to what we did there, to do more work. We certainly know the place well now. We know the chamber well.

ROSS-NAZZAL: What's going to happen with all your hardware? You mentioned all the stuff that you brought down. Do you envision reusing that for other programs?

SCORSE: It's all going to Goddard. It's all government equipment. There's a program up there they call WFIRST [Wide Field Infrared Survey Telescope].

ROSS-NAZZAL: Yes. I think Gary told me he's working on that.

SCORSE: Yes. Some of it may get used there, some of the optical equipment. The optical equipment is probably the only stuff. Some of the thermal telemetry equipment will be reused for sure. … These payloads are all very different, and it's very hard to come up with infrastructure that's just universal. … Like I mentioned, some of the big [hardware] is still here. I think it's going to get excessed right out of Johnson because of the size of it. The optical stuff will probably get reused.

ROSS-NAZZAL: Looking back, what do you think are some of the more important lessons learned during the test, or even as you started working on plans when you were one of the first two guys working on these concepts?

SCORSE: I think there's a lot of them. Obviously up front, early on, requirements are really important obviously. Getting requirements developed takes a long time. I think sometimes it's overlooked how long it's really going to take to get the requirements put together. It tends to cascade work. As I mentioned, requirements require verification, and it's either by test, measurement, or analysis. Any time it's test, it's a new job.

I think getting your head around the big picture and still being able to work on a small picture is a real skill. We have some really really good people: Lee Feinberg, Charlie [Charles B.] Atkinson, Gary Matthews. There's a bunch of people. They had the big picture, and they could focus on the small stuff at the same time. It's really important to have that. I think you can get out of control pretty quick if you start down a road too far and find out that, "Oh, I've got to go back and figure out that this needs to be verified or that needs to be verified. I need a test over here, or I need a test over there."

I think having a good understanding of what the product is and what it's going to take to bring the product together and keep it updated. What else?

You need good people. I think the program is a testament to people. All these programs, whether it's the Shuttle or Chandra or James Webb. It's extremely dedicated people. They get involved, they get immersed in the stuff, and they become assets. You need them. I think some of this stuff, if it ever got to a point it was plug-and-play, I don't think anything would ever work right or be the same. … An engineer is an engineer is an engineer, but when you have somebody that's worked on something a couple years, you really don't want to lose them. There's too much knowledge there. There's too much background. They do understand that, but it's priorities and whatever you have to deal with with your own company that can shape things one way or another.

I feel like I've been pretty lucky with the engineering community I've had and the assembly community and the technical community that I work with in my own company. I've had a good rapport with all of them, and they've all done good work. Hasn't been really an issue. …

It's like I said, it's the details. I don't mean to be stuck on details. But when you get 16 guys on the floor with wrenches and the parts show up and an inch-and-a-half bolt comes in at an inch and a quarter, and it's the wrong thread pitch, the whole day stops because of a screw. It's hard to explain to anybody sometimes three months earlier why that screw is that important and why you can bark at them.

One thing I learned is there's a standing army. Once you get to a facility and you're actually doing this stuff there's a standing army, and you've got to understand what can make that standing army stop. When you really look at what can make it stop, there's a lot of detail in there that has to be looked at.

ROSS-NAZZAL: Who would think of a screw? Obviously that must have happened to you at some point.

SCORSE: … It drove me crazy. Like in the clean room, we had to be above 40 percent humidity in order to even work around electronics because of ESD [electrostatic discharge]. So even if there was a bad change in weather here and something affected the humidity, and you drove it too high or too low—we actually had it go too low once. I think some of the equipment wasn't working right. We had a standdown. You couldn't touch the equipment because of static, which is a big deal.

It's not just with a screw or it's not just with a part that may have not been fabricated correctly or a piece of electronics that decided not to work when it came out of the box. There's a million things you've got to think about. "What's going to hurt you today?"

Just keep moving forward. You got to keep moving forward. You can't stall. You can't lose momentum. Even if you get stuck with the stuff, you got to figure out a direction and turn the momentum into it. Just get it done and keep going. It's like anything else, it's like leading a bunch of kids down the street. If you stop too long you start losing them. You got to keep driving forward.

ROSS-NAZZAL: It sounds like you had a very focused team, very interested, and passionate about what they were working on. I just had a couple more questions for you. What do you think was your largest challenge as you look back on the test program itself?

SCORSE: I think the biggest challenge was the time as duration. As I said, we came here in '13. We just left here. That's a very long time to be off site working six and seven days a week, trying to manage up to 60 people rotating. It's a really long time. It's a long time to be away from home.

You can't get back all the evenings you weren't at home and all the weekends you weren't at home. It adds up really fast. The thing I noticed myself was the first year you're gone, the first year you do it, you lose a bunch of nights and a bunch of weekends. The second year you lose a bunch more. It's got more of an exponential effect on you than it does linear. It's not like I lost 10 nights, I lost 20 nights, I lost 30 nights. All of a sudden somewhere around the third year it's like I've been gone a long time. Things just start feeling different. After five years you got to almost reestablish yourself back at home. It's an interesting feeling. It's probably the biggest challenge.

Personally a couple of my kids got married. I've got two grandchildren now. Five years is a big span. A lot happens.

It was the same way with the help that I had down here. I was amazed toward the end of the program how many people who were down here were grandparents that were still working on this telescope. A number of us had lost parents through the time we were here or had to put parents into homes. On the personal side that five years, with a lot of people that were here probably in the age group of 50 to 60, a lot happens in those years. Kids are going to college, getting out of college. There was a lot going on. Trying to manage the rotations, the workflow, around people's personal lives and impacts of everything was something that was constantly there. It's something you had to work with.

Over the period of the program, because it was so long, there was a lot of attrition, from people leaving the company to people moving on to other programs to people getting promoted to supervision. All kinds of things. You think you got a key person. As I mentioned, you don't want to lose a key person, but sometimes you do lose key people. You have to get used to it, because if you're going to deal with an 18-year-long program, very few people are going to be left standing at the end.

It's something, as I mentioned before, you have to keep moving forward with. You can't let it slow you down. You just have to find a way to get around it and keep moving.

ROSS-NAZZAL: Was burnout a major issue for your company, or as manager, as you were looking at your folks?

SCORSE: I don't really know of any burnout. I don't know if there was really any burnout as much as it was—I know several guys since they've left here have like—"It's like oh my gosh, it's been five years. I got so much work around the house that hasn't got done in five years," and blah blah blah.

Honestly, you get used to sleeping in a hotel bed and eating in a breakfast room. It's different when you go home. After a while it's just different. I still see all these people. Right now they're getting reintegrated back into other jobs back in Rochester. So I see quite a few of them, and it's all the same kind of thing. It's like stuff they haven't done in forever. They had a motorcycle. It's been sitting for five years, now it doesn't run. Just that stuff that five years does to you, you know.

ROSS-NAZZAL: What do you think was your greatest contribution or accomplishment?

SCORSE: My greatest contribution. I think it would be just keeping things together and moving forward. I put a lot of time into pushing the schedule, pushing the lower detail of the schedule to like I said keep moving forward. It's something you got to do every day. I use this term. I'm going to walk around and kick chairs. I'm not big on e-mail; I'm not big on phone calls. I like walking around seeing people, just keeping things going in the right direction. Trying to know something about everything that's going on.

ROSS-NAZZAL: What are you working on now? Are you still closing this out?

SCORSE: It is a tremendous amount of work to close a program out. By the time you make sure you've accounted for all the assets and materials that are left over, going through the government transfer process. We have to organize and maintain the records on the program for 15 years after launch, which right now is [2036]. Then we've also got to show the government that we've delivered everything that was in the contract. There are documents [that] you have to show that all those have been delivered or they're available for delivery. There are literally thousands of those. I [probably had] five engineers working on just gathering all this [information]. We have a formal/informal technical document we have to write that summarizes the program. There are a number of things going on. That's going to go on for a little while longer.

We're still running some support. We'll probably run a little bit of low-level support through launch, probably be very low level, probably a couple people at the most.

ROSS-NAZZAL: I think I've run through my list of questions. I always give people the opportunity to add any additional information or talk about something that they might have wanted to discuss. I wasn't sure if there was anything you thought we haven't covered.

SCORSE: No, I think you covered it pretty well. It's really hot down here.

ROSS-NAZZAL: It is, yes. There's lots of mosquitoes too.

SCORSE: It's hot down here. Somebody made a comment one day that the Sun is only a mile from the Earth here.

ROSS-NAZZAL: It does seem like it some days.

SCORSE: I know. Overall I think everybody did enjoy the program quite a bit. Aside from being here for five years, people made a lot of friends amongst their coworkers in these other companies. It was interesting. There's Northrop Grumman. There's Ball. There's a company called Genesis [Engineering Solutions]. There's ATK. There's Minus K. When everybody's here we really did work together, because it was a common problem, common effort. It was not siloed. People got to know each other over the years. In that respect it was a very positive experience.

ROSS-NAZZAL: Definitely heard that from a lot of people. That this was a very complicated test, but things just went off really well. What do you attribute that to? The fact that things weren't siloed, that things worked so well, people got along so well.

SCORSE: I think it's just the nature of people that get attracted to this, in part. I think it's partly the fact that we're working on a common thing. Everybody had to contribute for the whole thing to work. We had to work with each other just to incorporate everything into this hardware and everything else that had to get done. I think a lot of people have similar backgrounds. There was a lot of people with similar interests too. I think it was a sandbox.

ROSS-NAZZAL: Thanks again for coming down today. I really appreciate it.

[End of interview]