NASA JOHNSON SPACE CENTER ORAL HISTORY PROJECT
EDITED ORAL HISTORY TRANSCRIPT

DR. BEGOÑA VILA COSTAS
INTERVIEWED BY JENNIFER ROSS-NAZZAL
HOUSTON, TEXAS – 29 AUGUST 2018

ROSS-NAZZAL: Today is August 29th, 2018. This interview with Dr. Begoña Vila Costas is being conducted in Houston, Texas, for the JSC Oral History Project. The interviewer is Jennifer Ross-Nazzal. Thanks again for taking some time, especially on this very wet rainy windy day. Oh my gosh.

VILA COSTAS: My pleasure, Jennifer, thank you.

ROSS-NAZZAL: Thank you so much. Tell me how you became involved with the James Webb Space Telescope [JWST].

VILA COSTAS: I was working in Canada. I was working for the company that was [selected] by the Canadian Space Agency to do the contribution for the instruments on the James Webb from Canada. Initially I started doing some of the performance analysis, as my background is in astrophysics. I became more and more involved on the systems engineering part, making sure that all the requirements were met, supervising what testing needed to be done, which things could be done by analysis, etc. I moved up to become the systems lead and then the technical lead for the fine guidance instrument [Fine Guidance Sensor, FGS], which is the Canadian contribution.

We also have another instrument on the same bench, which is now called NIRISS, Near-Infrared Imager and Slitless Spectrograph. Most people, when they think about the Canadian contributions, think about the guider, because the guider is critical for the mission—and we can talk some more about that. It's very important for the Canadian astronomy community and others around the world that we have a science instrument to support James Webb as well.

I [worked] closely with NASA, of course, as they [were] collaborating with all the foreign partners. As well as Canada, the European Space Agency is involved in the James Webb. They are providing two of the instruments, NIRSpec [Near Infrared Spectograph] and MIRI [Mid-Infrared Instrument], so there [is collaboration] with [them] as well.

In Canada we used to meet regularly. I believe NASA was happy with my work. Once we delivered the flight model to NASA they asked me if I would join their team to work directly with them rather than through the Canadian agency. I must say it was clever of NASA to do this because once the instrument is with you it's good to have expertise in house for that instrument, so they did that for FGS and NIRISS.

They did it also for NIRSpec and MIRI. They brought the systems lead from Europe to work directly at NASA. The other instrument, which was NIRCam [Near Infrared Camera], was already a USA instrument, so they already had the expertise in house. Then I just continued from then onwards with NASA.

ROSS-NAZZAL: When did you start working out at Goddard [Space Flight Center, Greenbelt, Maryland]?

VILA COSTAS: I started in 2013. When we delivered the flight model, at first we ran an initial cryo [cryogenics] test at Goddard in the chamber there. That cryo test had only two of the instruments, MIRI and FGS/NIRISS, which were the ones that were available at that time. When all the flight instruments were available, we ran a second cryo test. We timed my transition to the end of that cryo test, so we kind of already knew when I was supporting that second cryo test that I would be [transitioning to work at Goddard], but we waited until it was completed successfully. That was at the end of 2013.

It was [also] very good for me to move [to] NASA, because I felt I was already at the top of what I could do with the instrument by itself. Once you work on the next level up, and you are integrating all the instruments together—I'm sure we'll talk [about] the mirrors and the rest of the telescope—then you have that extra visibility and extra items to work with and to grow with. That was very good for me, and in fact I was selected as the cryo test lead for our third, final cryo test of the instruments. That's a little bit similar to what was done at Johnson, but only involving the science instruments, so it would be [in] the chamber [at Goddard] making sure everything works as it should. At the end of that cryo test we can [confirm that] the instruments are ready. We think they work as they should. They met all their environmentals, acoustics, vibration, and being functional in cryo, and here they are.

In parallel with that cryo test, the mirrors were being assembled. Those two activities were happening in parallel. You know when you have a schedule, you have multiple components, you are trying to [complete the parallel ones] at the same time. This is what was happening. They were assembling the 18 mirrors in the clean room at Goddard. We knew we had to finish [the instruments' cryogenic test at the same time], and we did.

At that point we can [integrate] the mirrors [the OTE: Optical Telescope Element], which is what everybody sees, the big mirrors, with the instruments. The instruments go on the back of the mirrors. There is a black box when you look at [JWST] where the instruments are housed. That's what happened at Goddard, we put them together, and then we started to get ready to run the test at Johnson with both [components] together.

ROSS-NAZZAL: We're primarily going to talk about the test here at Johnson. But can you talk about that test up at Goddard, that cryogenic test, and what you learned? Did it have any impact on the way that the test was going to be run here, the OGSE [Optical Ground Support Equipment] tests and pathfinder tests? Did it have impacts on all those?

VILA COSTAS: Sure. When we were [testing] with the instruments, we have only the instruments, we don't have the mirrors. You have to have ground support equipment, a simulator, for those mirrors, so we had that. We learned different information about how the instruments perform, how they can be operated.

You always have more tests that you want to run compared with the amount of time you have. You have to do parallel [activities]. That helps a lot to improve the efficiency of the test, but you have to be careful. Some of the parallels are good because you will be doing those parallels on orbit, so of course you want to test them. Some of them are things that you want to do to gain time. You have to make sure one thing doesn't interfere with the other.

We did a lot of that. The testing at Goddard was 110 days. We did do a lot of that optimization [to fit all the tests needed]. We learned very well how to operate the instruments and how [the parallel activities] would work.

In parallel with this [test at Goddard], they were testing the chamber here [at Johnson]. [The] goal of the test at Johnson is [going to be to verify the OTE], the mirrors. The instruments have already been tested. We want to see if the mirrors deploy, if we can align them, etc. To know that, you need to use the instruments to take the pictures; a lot of [the testing] will be done as it will be done on orbit, taking images with the instruments.

Prior to us coming here, the chamber had to be validated. I'm sure you have all the information of the different tests that were run to make sure, with all the changes that were made on [Chamber A, that] it was ready for James Webb.

One of [those] critical [tests] was the pathfinder, with a small subset, three, of the mirrors, to confirm everything was working as expected. A very important thing when you're working in a chamber—and that applies both to the instruments, so [to] the test at Goddard, and [to] the test here—is your cooldown and your warm-up. That takes a long time, and you want to optimize it, make it faster, but you have to be careful that you don't exceed the rates of cooldown that would harm the hardware, or rates that could create gradients within any components [in] the hardware that will give you a wrong answer, or, even worse, harm the hardware. [So] you are working with speeding up that cooldown and that warm-up to save time, but at the same time doing it safely. That's one of the [items] learned with the pathfinder [test].

A big difference when working [with] the pathfinder [is that] they also needed to take images, so they had a detector. That detector was more of a point-and-shoot [camera] I want to call it. You pressed it, and you take an image. One of the things I noticed at the beginning was [that] the [optical telescope (mirrors) team were] used to this. We already knew from the instrument side that once you had the instruments [taking the images], it wouldn't be like that, because they are complex instruments in themselves. I became the point of contact, the lead, from the instrument side to coordinate with the mirrors side. "How are we going to work together? What things can we do?"

They would say, "We want to take this picture. This is how we did it with our point-and-shoot detector." I [would] coordinate with all the SIs, with all the science instrument team members, and say, "Well, you cannot do it like that. We need to do [these things] first: we need to initialize the instrument; we have to make sure the mechanisms are initialized properly, [etc]. You [need to follow] this sequence that maybe you didn't need to worry about before, but now you do because you are working with the flight instruments and you have to be very careful with them."

I think that took a little bit of adjusting on both sides. I want to think I helped with that to make things go smoothly and as best [as] we [could] for the test.

ROSS-NAZZAL: When did you officially come down to Johnson to start working on the test? Was there any work up at Goddard done prior too?

VILA COSTAS: Yes, when you're running a test, you're going to run these procedures. You're going to determine what are you going to test. You're going to have an overall plan how to test it, and then you're going to be writing these procedures. Many of them, it can be, I don't know, I'm trying to think, 60, 70 documents that detail step by step what commands you're going to be sending. That has to be vetted by the whole team. You have to start from the beginning and say, "I'm going to power the spacecraft. These are the steps to power the spacecraft. What do I want to do next? I want to power one of the instruments." Then [confirm] the steps to power that instrument. "What do I want to do [next]? I want to move a mirror, these are the steps to move the mirror. Then I want to take a picture here. Then I want to move the mirror again. Then I want to take another picture, etc."

There is a lot of work, a year's worth at least of effort, that involves the whole team, to choose which activities you're going to run. You have a wish list at the beginning. Obviously that is not going to work [as the test would take very long. For example, it could] take 150 days. We are told we have a certain amount of time, [e.g.] 100 days, so we have to work to [fit the tests to that duration].

You have a priority, and you select the high priority tests. Then you are going to put some estimates, how long this is going to take. But you always have to put an uncertainty factor there. [For example], we all plan things in life. "Tomorrow I'm going to do this, this, this, and that," and the first thing you're going to try, well, your car doesn't start because you forgot to put gas in it, so that immediately delays you. You have to add that to the test. You can have a very optimistic schedule that will get blown as soon as you start, so that's no good. You need to put a factor there. It was normally 40 percent, which is a large factor, but it's the first time you're testing two things together, so you have to be careful. Then if things go well, awesome. You have extra time, and maybe you can pull in some of those extra tests. But more [than] likely, some parts will go well, and other parts will give you more trouble, as happened at Johnson. You find things that you are not expecting, and you want to investigate them. You need to have some extra time to do that investigation without upsetting the [overall] flow.

A lot of this planning is done beforehand. Then you have activities you have to get ready here, so you start traveling. We travel to Johnson more often as we get closer to the test time. We have different reviews. First the smaller ones, then bring in a bigger [team], to make sure we are covering all the bases.

We have in particular these test readiness reviews, which have a board that will say, "Yes, we think you are ready to start the test," or, "No, you have these [items] that we want you to fix before we agree that you're ready." Then once you start [the test], you [are based in Houston], so I was here a lot. Starting in June, I was here almost all the time. You go back home a little bit, but all the way throughout the 100 [test] days, I was one of the ones that was here often, including through Hurricane Harvey, which was an unexpected event as well.

ROSS-NAZZAL: Yes, for everybody in the city. Were you here when OTIS [Optical Telescope Element and Integrated Science Instrument Module] arrived?

VILA COSTAS: I wasn't here exactly when it arrived, because that involves the integration and the transport team. They need to do a lot of prep work to get it ready and also a lot of work once it's ready to connect all the harnessing and make sure it's [ready]. During that time I would only come once in a while for a meeting or to review a particular item, because my expertise lies once everything is connected. We are going to power things up and check that they are [working] properly. That's where I come in.

I follow everything else before in the sense that if you don't have something ready, this harness or this item needs to be substituted, me and other team members can provide our inputs to say, "Yes, that's acceptable," or, "No, that's not." The same [for] the software that we have to run. Everybody has to agree which version of the software [to run] for each of the components. We have many of them. Again we can provide inputs. Maybe that portion is not ready, or maybe we need a patch. This kind of thing. Then you can say, "Yes, that's acceptable," or, "No, we really need to wait for that to be ready."

Once we are ready to do the first functional [test], we are going to power things up, then yes, I come here. I'm typically one of the ones that is around to make sure, either on my shift, or if it's not on shift, [still] there. We had a role which was the ISIM [Integrated Science Instrument Module representative (ISIM rep)], so the instruments lead during the test, [and I was that person]. I was one [of two people] coordinating [this role], as the test was focused mainly on the mirrors and operations for the mirrors for their verification, but to make sure the flow of information went to the instrument teams, if things were going well or if they were not going well. They needed to know because the instruments were [being] operated, so we had a point of contact to make sure all the information was there. I was overall organizing that point of contact and then on shift indicating when different [tests] would happen and [other items].

ROSS-NAZZAL: Can you talk about that? Who were you communicating with and how were you communicating? Was that globally?

VILA COSTAS: Yes, I think you know Carl [A.] Reis, Lee [D.] Feinberg [were the overall] leads for the test. Then we have a set of what we call test directors, which are one per shift, that oversee what's happening on that shift. I am part of that group, so I would be a test director based on the schedule. [There was also the ISIM rep who would coordinate items on the instrument side. Myself and Scott [D.] Lambros were the overall ISIM rep leads for the test.]

You also have one or two test conductors. Those are the ones that have the procedure that we're going to run. They're going to be saying, "Yes, I'm good to [do this activity]." Always checking with the test director or whoever is needed.

You have the test operators. Again, one or two, which are actually sending the commands per authorization from the test conductor and in agreement [with the test director and subsystems that are going to be operated].

You have a very important parallel set [of leads and operators], which are provided by Johnson, related to the chamber. You have a test director for the chamber performance. The chamber is going to be cooled down or warmed up or whatever is happening [and is being] monitored. They have their own set—the team at Johnson. Other things might be happening in the clean room or on [parts of the building] when we are testing, so they will coordinate [those activities]. They will say, "Oh, we are getting a delivery of this," or, "We need to run this activity, is it okay to do it during this portion of the test?" That test director for the chamber at Johnson worked very closely with the [overall] test director for the activities, so we have this parallel [coordination] going on.

I think you have seen the control room. You have the different stations for everybody that's involved in a similar way as they would be on orbit, a station for each subsystem. Before you send a command you will call on the loops and say, "We are going to take an image or move a mirror. Is everybody happy?" Everybody will respond yes, yes, yes before we proceed. You have a [station] for the instrument teams as well. They're on console monitoring [their] instrument.

A lot of what was happening was in the main room, where the [main] control [room] was. There was another room set up for the instrument teams, and there was another room in the other building—so we were using Building 32 and Building 30—for the data analysis with again a large team of analysts.

The TDs [test directors] and the ISIM rep were very engaged with what was happening with the main TD and in the main room. We sent shift reports every shift, three times a day, but those [reports] are more top level. Let's say we think this activity is going to be delayed, [as] the mirror team needs to do some analysis before they do the next mirror moves.

We know an activity was coming up where we wanted to take some darks for one of the instruments, for NIRCam, and we were going to wait for the mirror activity [to complete]. But now because the [mirror team] needs time, why don't we [do] the darks [instead while we wait]? You're again trying to optimize time. That would be coordinated through the SI lead. The SI lead would have a certain knowledge, and we would say, "Yes, we think that's possible for that instrument. Maybe it's not possible for this one because of whatever reasons. Let me go and talk to the SIs and confirm if they are okay proceeding."

It was a little bit that making sure, which I think is always very important, that the communication was there for all the levels. You don't want to have meetings with a large amount of people. We all know you do want to disseminate information, but when you're trying to make a decision, if you have a very large number, particularly with different levels of expertise, you can spend a lot of time explaining things or discussing things that maybe are already covered. But [it's] very important that you do have the inputs from everybody, so that's why I think it's always good to have these leads that will gather all those inputs, have whatever discussions they need to make sure they're okay. When you have the top level meeting you can provide that feedback and move it forward a little bit. We were doing that at different levels with the different subsystems and the SI lead was one of the ones in there.

ROSS-NAZZAL: You mentioned something called darks. What is that? Can you explain?

VILA COSTAS: Yes. When you are working with a science instrument, you are going to take an image. That image will have certain artifacts depending on the background. An example could be if you take a picture with your camera and it's a bright day. It's on the beach, and you didn't set the exposure correctly. I'm taking a picture of you, but [if] the background is really bright, I will have the picture, but you'll probably be not optimal because there is this background there.

The same thing happens when you're observing on orbit. Your detectors have certain peculiarities that you want to remove. What I could do in the [example I used], would be I could take a picture of that background without you, then I could take a picture with you, and then I subtract one from the other, and I'll be able to eliminate everything else.

This is what you do in particular for the detectors for James Webb that [are] optimized for the infrared. They are very well understood, but they have this background behavior. Each of the pixels, and we have a lot of pixels, millions of pixels there, behaves slightly different when they are read and also behave slightly different depending on your background conditions. Before you go and launch on orbit you get what we call darks. You try to remove everything external [and capture the internal behavior of your detectors]. The instruments might have shutters on their filters that you can put in, so as [to make it as] dark as you can [to remove external light effects on those dark images]. You take these [dark] images that are very long. It's hours and hours, because you are looking for very tiny variations that will become very important once you're on orbit. You need to have a lot of them. You need to accumulate a lot of time. It's something that will be seen as a lower priority [activity], because eventually you'll do it on orbit, so it's something that you try to do in parallel [with other activities]. You don't want to use prime time to get these darks, but you do want to get them, so it's something that the SIs are always looking to get.

If I'm taking an image with NIRCam [related to the main test], in parallel I could take my darks with NIRSpec or NIRISS, and that was one of the activities we did a lot, that again the SI lead coordinated, because the mirror team perhaps is not aware so much of this, whilst we are. We will look for any opportunity to say, "Oh, you're not using this [instrument] for two days, can we just be taking [their] darks while that [other activity] is happening? Or do this other [test] that doesn't affect you, but it gives us information that we need [for another instrument]?" That kind of thing would be happening.

ROSS-NAZZAL: Did that happen quite a lot during the test?

VILA COSTAS: Yes, it did. It happened a lot on our CV3 [the third cryo-vacuum test of ISIM], at Goddard. Our chamber was perhaps a bit darker because it's a smaller chamber, though at Johnson we did get to very good [dark] levels. Because you're working on the infrared, and this is an effort that again the whole team does before going into the chamber, anything that's warm is going to generate background light that these sensitive detectors will see. A lot of effort at the beginning is done on the chamber and on anything you put in the chamber, any harnesses, anything that's at a warmer temperature, either blankets or covering, to make sure you are as dark [as possible.]. Dark means cold, when we are talking infrared. It means if something is a little bit warmer—the instruments are operating at 40 Kelvin—so anything that's a little bit warmer we'll see glowing if you take an image, so you don't want that. It's blanketing, making sure nothing [warmer] is there.

For James Webb it's a big challenge, because the electronic boxes don't like to be that cold. They like to be at room temperature. Indeed, they're at room temperature, and other components are warmer too. You have to make sure they are in an area that is covered so that heat does not transfer.

I think you might have talked to the mirror team. I don't know if this came up. They had the setup of three mirrors [(Auto Collimator Flats, ACFs)] on the top where they were able to bounce the light from the fake stars to do [portions of the test]. For some of that setting they [used] what we [called] the COCOA [Center of Curvature Optical Assembly that is at warmer temperatures, but that has a] shutter. When that [shutter] is open there is warmth, the chamber is warmer. That's not a good thing if you are trying to do something sensitive with the instruments, because that warmth, they will see it.

There were activities that you could do when that [shutter] was open, and activities that you would request: "We need it closed. We need it closed, and we need to wait a little bit, because it was open, so there is some heat that needs to dissipate." This is important in particular for two of the instruments. It's important for all of them, but NIRSpec, MIRI, and NIRISS have filters that they can put in place to [block that warm light so] if you open that [shutter] on the top of the chamber, I put in my filters, and I have something I can do, because I can [make my field of view darker with those filters].

We have two instruments, one of them is the guider, which is [one of] instruments [I look after]. The guider is always open to the sky, it's what it does. It's looking for stars, so we cannot close it, so we will see any warmth that's out there. If we want it to do guiding, sensitive measurements—and I'll tell you about one of them that we wanted to do for this [test]—we knew that COCOA shutter had to be off, closed, so we didn't see any [warm light].

The other instrument [sensitive to that warmth] is MIRI. Most of the instruments from James Webb work from about 0.5, 0.6 microns to about 5.5. MIRI is the one that can go up to 28 microns, so further into the infrared. They have their own cooler, their own [freezer], so they [cool] to 6 Kelvin instead of 40 Kelvin like the other SIs. This is awesome, because that's what we want. We want to look further into the infrared, but the further into the infrared you look at, the more sensitive you are to this heat. If the instruments that are operating at 40 Kelvin are sensitive, MIRI that is operating that much [colder] at 6 Kelvin is [very sensitive]. So that was another instrument that for some of their activities you needed to make sure that there was no warmth in the chamber, everything was closed. All of [these] are [items] that you are aware of that again, at the beginning, the mirror team were not.

I'll tell you something else at the beginning, an anecdote, where again I think they were more used to the point-and-shoot. I press a button, this camera is ready, and I can take pictures. To bring all of the instruments up [takes] hours. If everything goes well, it's about two shifts, 16 hours. Each of them takes a different amount of time, so maybe you only need to use NIRCam, so we can bring NIRCam first, but that's going to take 5 or 6 hours. You can't say, "Oh, I want to take a picture now." We have to know that you want to take the picture. Similarly so for each of them. When you are saying, "Oh, I want a picture with all of them," okay, we need those 16 hours.

That [time] is already planned and the instruments have also certain requirements. They need to be turned on at a certain time during that cooldown. All of that is a part of this planning that I mentioned before. All of that is worked [out], so we know when things are going to happen.

We had tested really well when we were at Goddard. Software is always changing, you are always improving things on your software, and we have a particular software that we are going to use when we are on orbit that we test as much as we can, but it's a complex software that takes longer [to optimize]. When we had an opportunity to test at Johnson, we wanted the newest version. We had already tested [with an earlier version of this software], but—[it] happens with all the apps on our phone and everything now, a year later we have an improved version, so we want to test with this. That is what you need to do, but that always carries certain risks, because it is the first time you are going to use it [with the flight hardware].

So I mention this anecdote because the mirror [activities are] happening. We're cooling down; we reach the time when we have to power the instruments. So which one is the first instrument? NIRCam. How long is it going to take? Six hours. We start. The software trips on something, and the instrument doesn't come up. The instrument team, they quickly know what it is. It's nothing, no major problem, but a patch needs to be generated, needs to be validated, etc. That takes time.

This activity that was supposed to take 6 hours takes now 12. The instrument teams, everybody that is familiar with this, they were happy they knew what it was. It was relatively straightforward to identify after the initial [stress], the initial, "Why is it not working?" They were able to work out why not, generate a fix, and then [the instrument] came up. Great for the instrument team.

You have everybody else, the mirror [team and others], which are not used to working with the instruments. They're like, "Well, this is unacceptable. You said 6 hours, and it's going to take 12. We are not going to be able to work like this." This is the first reaction. We wanted to take these measurements, and all this extra time has gone.

I remember being on that meeting, which was a little bit tense—to say, "[Items like this are] going to happen. This [time it] was us. It will [also] happen to you." As it [did, the] mirror team had their own challenges that came up and delayed things on their side. We had this meeting where you say, "This is going to happen. It's understood. That's why we test. That's why we do the next software."

I remember being at that meeting and knowing the next instrument that was going to come up was NIRSpec. NIRSpec also has complexities. When I left, I already knew I wasn't going to suggest we do NIRSpec next. I wanted to do my instrument, FGS and NIRISS. Not because it was mine, but because I knew the changes on the software from what we tested at Goddard and what we tested at Johnson for all the instruments. I knew ours was very solid. We hadn't changed very much. I was expecting we would come up quickly, in the 4 hours that we were supposed to.

Because you sense how the team is feeling, I wanted [for them to] have a good experience, before we went into another [activity], that might or might not present challenges. That's what I argued [for], and everybody agreed. Sure enough, I'm waiting, still with bated breath, as you do, because you are hoping [all goes as planned], but [with a] test every time is different. Indeed, my instrument came up as expected, 4 hours. Everybody feels a lot more relaxed. It's not the end of the world. Then we proceeded with the next instruments, MIRI and NIRSpec, which I'm happy to say they also came up more or less as expected.

Again I think it's more two teams learning to work together, which I think we did. I think by the end of the Johnson testing we had the instrument team, we had the mirror team, we truly were the OTIS team at the end. We knew the nuances of everybody. [The instrument team also understood better why the mirror activities took the time they did.] We are a new team now, an OTIS team.

I feel we are facing similar challenges now. As you know, we are in Los Angeles [Northrop Grumman Aerospace Systems' Space Park]. We have to join the next [components], which [are] the sunshield and the spacecraft. Again they [have] their [own] team. They know how they're doing it. From my experience coming through [the integration of previous components with individual teams], I can see the same kind of initial, "We do it like this."

"No, we do it like this. We need it this way."

"No, we need it this way," which I think after our testing there in the next year or year and a half we'll become the new team that will serve us well when we are on orbit, which is everybody operating together. I think every time you join teams you have this.

ROSS-NAZZAL: Right, that tension.

VILA COSTAS: That tension, or that good new knowledge, and that new way of working together, with the different leads of course, and handshaking between everybody.

ROSS-NAZZAL: How long do you think it took you guys to come together and become one team?

VILA COSTAS: I remember a little bit of frustration. I know more how it was on [the instrument's team side]. I'm sure [the mirror team had] it on their side. In the year leading up to the test, at the beginning when we started working together, "We are going to do it this way."

"No, you can't."

"Yes, you can." On both sides I'm sure.

I think it was a little bit at the beginning, like the example I mentioned. If things go well, everything goes well. I don't think it took very long, I think after the first few weeks of working together we began to understand a little bit how to do the handshaking.

When the hurricane came, which we were planning for, but we didn't know [for certain]—we were waiting to see. I remember the day before thinking, "Is the Center going to close?" The thought at the time was there will be time; it will escalate gradually. I was on shift that afternoon and coming first thing the next day, so I left. It escalated, I think as everybody knows, very quickly overnight, so when we woke up the next day the Center was closed.

You have the challenge that you have some team members onsite, but they are not sufficient to continue 24/7. The team here, Lee, Carl, everybody had already arranged replacements to come for what they were more aware of. Of course they were a little bit less aware of the instrument team. My first question when I talked to them, they indicated, "No, we are bringing test directors, test conductors. We are keeping everything to a minimum as far as any mirror moves or anything like that."

I remember saying, "Okay. We need the same backup for the instrument teams."

They obviously agreed, "Of course, of course." We set it up to bring a convoy of five trucks that brought replacements for all the SIs, so we would be able to sustain with the people onsite. It is a balance between not too many people onsite but enough people to cover the shifts. When we came in, of course they were not bringing anybody that operated the COCOA or the mirrors, they were not doing anything like that. So [at the beginning] we are on hold [as far as any testing].

The instruments had already [been] checked. We did our cryocycle, our testing at Goddard, so now we are just confirming everything is good after acoustics and vibration. The instrument teams have identified a set of priority tests that have been slotted, second priority and third priority. [We] are going to have a couple of days [for these tests to happen], where in theory we're not testing [the mirror activities which are the prime objective of the Johnson test]. I know what the instruments are planning to test, so [on that day, when everything is on hold due to the Hurricane], I indicate, "We don't need any of those team members. We don't need the mirror team. We don't need the COCOA [team]. With the people I have onsite now, my test conductor and my instrument teams, I can run a lot of the instrument testing."

They said, "Oh, can you? Okay, go ahead." It didn't take me very long to set up a two-day plan of tests where we could advance a lot of the activities [on the instruments side]. We started, to all the instruments' delight, because we could do [those tests] and use the time that otherwise we would be [just] waiting.

I have to say that didn't last very long. After one day of seeing how we were able to run, they decided to bring [in more staff]. I think I see on my side the different expertise used. It was very clear for me what could be done. I understood what the mirror team couldn't do, what they didn't want to risk doing, etc., until they knew how the situation was. The instruments were powered, we were on hold, there were lots of things we could do, provided we had the level of support that we had. That was very helpful.

Again another example of each team knows what they can do, and it's good to have the expertise from all of them to be able to [test efficiently]. That was good.

ROSS-NAZZAL: That's great. Can you elaborate a little bit more on the testing that you were doing and how it was different from Goddard? You mentioned acoustics for instance.

VILA COSTAS: Right. As it is standard, when the instruments were assembled together you do vibration and acoustics [tests]. You do ambient functionals that show you nothing is broken at ambient. Really the key test is being able to go cold because of what we mentioned before, the instruments work in the infrared.

Sure, at ambient I can see my detectors are still receiving signal. I don't have a lot of information, because they're all very saturated. We had run acoustics, vibration. We went cold, and we ran the cryo test. Everything worked great. We know we are ready. The instruments are ready.

The instruments then are joined with the mirrors, and the next thing you do is you repeat the baseline testing. What we call OTIS, the mirrors with the instruments on the back, go through acoustics and vibration, and they do ambient functionals again. Everything looks good. But what is going to be the key test? The key test is going to be when we are cold again. That was Johnson.

Each of the instruments had a set of tests, minimal testing at cold, to say, "Yes, everything looked great at ambient, but are we truly good at cold?" That was the high priority testing that we were able to [add] to indicate, "Yes, the instruments are still good to go."

One of the instruments, which is my instrument, the guider, had another very critical test. The guider is going to be responsible for the pointing and stability of the observatory. That means—again using a common analogy—if you are going to take a picture with a camera, you need to keep the camera steady. If the camera is moving, your picture is going to be blurred.

When the spacecraft is on orbit, they have a coarse pointing. They keep things pointed to a certain level of accuracy. Once you want to start taking image data and aligning the mirrors, you need a much finer pointing accuracy. To do this you need to engage the fine guidance system for the James Webb. What happens is you choose a guide star in the sky. The guider takes an image of that guide star every 64 milliseconds, 16 times every second. It tells you precisely, with a very high accuracy, where that star is, and keeps [telling you] to a very high level of accuracy.

If that star is moving a little bit—as they will do on orbit—you have a fine steering mirror and an attitude control system. They receive the information from the guider, and they determine how to move that mirror to keep the star steady within the rate that the science instruments need.

Up to now, at Goddard, we have been able to test the guider. We have a pretend guide star and a pretend steering mirror and a pretend attitude control system. We know all of that is working great. We don't have the real thing.

Johnson is the first time, because the big mirrors and this fine steering mirror are there for the first time for real. We still don't have the final software and the final spacecraft software for the attitude control system, but we have a good version that we are able to test with. This test, the fine guidance loop, was the first time and the only time we are going to be able to test it until we are on orbit. It was a very important test.

You would set a fake star. You would be able to move that star. The guider would read the position, it would send that position to the attitude control system, which would then confirm with the fine steering mirror move that we were able to keep it within the accuracy that we needed. There were lots of challenges because the stars that we were using at Johnson were designed to align the mirrors. They were not designed to check the fine guidance system.

I don't know if you have seen some of the pictures. We have two types of stars. One of them was like a big blob, what I call a blob. The big blob moved a lot, had a lot of vibration in the chamber. That meant there was too much movement for the kind of tiny movement that we are looking for [in the fine guidance closed loop test].

The other type of image was much steadier, so very good for guiding, but it was very distorted. It looked like a bird. I don't know if you were able to see [examples]. On orbit we are going to be working with a little star that when the mirrors are defocused, it will look like a blob. It will look like the first star [on the Johnson test], but it won't move as much. It won't have as much jitter. In this case we are working with a kind of bird [image], I don't know how to say, it is like a [curved line].

ROSS-NAZZAL: Concave?

VILA COSTAS: Yes, a half shape. We had to make modifications on our software to say, "It's a bird, but pretend the image is good." There was a lot of work involved, making it work with this type of guide star. This test was very important, and it was very successful.

We ran it through 36 hours straight. I was the test conductor throughout it. It was a team effort of course, working with the Northrop team, as they are responsible for the attitude control system, and working with the fine guidance system, which is the team from Canada, and then with support from the software that we use on orbit, and lots of other teams. I think of it as my baby—the test, the execution, it was working with everybody, I felt.

It was an exciting 36 hours, maybe not for everybody, but for our team it was. It happened just after the hurricane, so we were slotted to start around the hurricane time. The teams that were supporting [it] were [in Houston], but they were all waiting in their hotels. I was onsite, because I was supporting the other testing. The way it worked out it was very good that the hurricane lasted the amount of time it did, which was not too bad. You don't know [how long it is going to last] when it's happening. We were able to then run the test straight after, almost a day after, for those 36 hours, and get great results, great data, that has since helped us to understand lots of things that we need to understand before we launch.

We are still looking at the fine details of that data because we ran for hours, and as I indicated we get 16 bits of data every second, so we have a large amount of data. The test was very successful overall but then you can start mining each little second throughout all that time to understand finer details that will be very useful when we are on orbit doing the real thing.

This is the only time we can do it with the hardware, because from now on we are at ambient, so we cannot detect any stars. Once we are connected with the real spacecraft and the latest software, we can just infer at ambient that things are working okay. Everything else we need to do on the simulators. Again from the knowledge of the test we can improve those simulators a lot. Then we do it for real when we are on orbit, and we have all these suites of backup plans in case.

You always try to [prepare] if something went wrong, where [to] go to have a set of tools that will help you to recover quickly. All of this is work that we continue to do. It was exciting. I always mention the guiding. It's exciting to see it. I think everybody gets excited when [you] see the guider [for] the first time, when you explain to people, "We got the star. We are tracking it. We are issuing this data." If everything works well, within an hour or so you are kind of bored, because what we do is [keep sending] this information 16 times a second. If everything works well, we [keep] sending it. It's totally transparent to everybody. If you are watching that in your screen, after the initial excitement that we are getting it, and it's working, and you are not part of the guiding team, I'm sure you are there thinking, "Okay, is this it? Are we going to do anything else?" For me that's what we aim for, that it's transparent to everybody else. We got the guide star. We are guiding. Everything works okay. Then the science instruments can start.

I find you become part of the background, but it's very apparent when it doesn't work. I know we do many rehearsals in preparation for on orbit. All the instruments, everybody just assumes, "Oh, I press this button and guiding happens. Then we can do [all these other things]." It's only when you [realize that] 'press this button' is a challenge for us, [the guider team]. If everything works, we are in the background, nobody has to worry, but when things go wrong it's very evident, because you cannot [observe with the other instruments as you were planning to].

ROSS-NAZZAL: That would be a huge problem.

VILA COSTAS: It becomes very apparent. It's one of these things that we hope to [avoid].

ROSS-NAZZAL: You don't want another Hubble incident.

VILA COSTAS: You don't want to be—I don't mean forgotten, [but] you're background when everything works well, because it's [working]. It's like when you switch [on] your computer, if it comes up, you don't give it any thought because you can do everything you need to do. If it doesn't, of course it's a big challenge. We want to be background, but we also have a lot of work that we do to make sure that's the case.

ROSS-NAZZAL: It's an important part of the telescope.

VILA COSTAS: Indeed, yes.

ROSS-NAZZAL: If it doesn't function you're kind of in trouble.

VILA COSTAS: Yes, we would be, and that would be very apparent. I hope we continue to work to make sure it doesn't.

ROSS-NAZZAL: I want to ask you, because I always try to be cognizant of time, it is actually straight-up noon. I don't want to keep you too long. I wasn't sure if you have meetings.

VILA COSTAS: I don't this afternoon. I don't want to prolong it, to take more of your time.

ROSS-NAZZAL: No, it's very interesting. A lot of this stuff people have not talked about. We've talked to some other people about different roles and how they were involved. We haven't talked a lot about the science. There's a lot that we haven't covered. I did want to ask you, since you mentioned that you were the test conductor during that 36 hours, if you would talk about that. You did mention the one challenge was the stars here at JSC. Were there other challenges that you encountered?

VILA COSTAS: Yes, I think the guiding itself is a challenge with those stars. It was the first time we worked with the attitude control system, to make sure we understand how they were going to react. It was another example of two teams coming together, and again we were preparing for that particular test for a year as well. We were traveling often to Northrop and running on the simulators to make sure.

I think it was just a combination of both. We make the star work. We call this information that we give every 64 milliseconds a centroid. A centroid meaning we are going to tell you how bright is the star, its position in the X direction, its position in the Y direction, and quality indicators. We are going to tell you it's good in width, in height, in brightness, etc., etc. If we think it's not good for any reason, we are going to mark it bad. The attitude control system doesn't want to use something that we don't think it's a good centroid. Anything bad, they're going to ignore.

However, they need information regularly. We have to make sure we don't give too many bads in a row because they [won't] know how to operate. It's a lot of interaction with each other to see how many bads can you tolerate in a row—as I said in this case, if this was a star on orbit for sure we have to tell you it's bad, but how can we trick it to say it's good, so you can use the data [for this test].

Then different updates on both softwares, and how we engage what we call the closed loop, which is when we are working together closing the loop to do the fine guidance. There were different things there that we had to work.

Then we had simulated images—from the pathfinder [I] mentioned before. Those are based again on this particular detector [used for that pathfinder test]. They didn't have the real instruments there. We had our test ready. When we took the first images with the real guider, the images did not look as they did from the pathfinder. It was a small change. I said it's like a bird, a set of wings. The pathfinder had a single eye on that bird. The guider is going to be looking for a bright spot on this window to track to say, "Oh, that's my star," because it's the brightest part on this image.

I'm simplifying a little bit. Lo and behold, when we get the image, when we are cooling down and we can take the first image for the guider, it has two eyes. We're like, "How can this be possible?" Now we have two eyes, so it's [not] going to work. That's because they were not using a guider on the pathfinder. They were using a single camera. The guider has an optical path that generates two eyes. Once we knew we had two eyes, okay, first understand why. Then we had to quickly, both the guider and the attitude control system team, we got together to confirm what parameters we wanted to use on the software with this new image, which is what we are going to have [for the test]. That was a challenge, because our test was coming up as well, so you need to be ready. What updates do you need to make? Again we were ready, and we did it. We managed to do it.

As I said, we found lots of good information from this test, of things that needed updating, both on the attitude control or on the FSM [Fine Steering Mirror] commanding and on the guiding as well. Small things, I mean everything worked, but you always want to improve things and make it more reliable if you can. That was something good there.

ROSS-NAZZAL: Were there any specific lessons learned while you were working on this test that you think other people should be aware of next time they run something similar?

VILA COSTAS: I think communication was key, for sure. That we already knew. That was important.

I think having this point of contact, particularly for ISIM, was very important. We had had some discussions leading up to it indicating, "Oh, no, once we are a team together, we are all good. We don't need to." I think it was proven no, having particular points of contact that made sure, particularly for these larger teams, that things are distributed is good.

The other thing we learned was, as I mentioned before, parallels. We learned quite a few things. We already knew from the instrument side what things could happen in parallel and what things could not. Adding the mirrors generated new things that we learned that we cannot do. Each of us was used to working independently, particularly for the guider. There are certain things. There is an activity—I'm sure [you have heard when you] talked with the mirror [team, the Optical Telescope Element team], once we're on orbit the deployments are hugely important. We need the sunshield deployment; we need the mirrors deployments. The next part is going to be to align those mirrors.

Aligning those mirrors is another example of the [wavefront] sensing and control [activities]. Again it's something else where people are mainly originally thinking, "Well, what do we need? We need the command to move the mirrors. The way it's going to work is I'm going to take a picture with the mirrors like this. I'm going to send my command to move these mirrors a little bit. I'm going to take another picture. I'm going to analyze it on orbit, on the ground, and I have a path [to align the mirrors]." The mirror team is excellent at this.

What do we need? We need the mirror team to [get the telemetry to] know [how] they are doing. And which instrument are we using? We are using NIRCam, because it's going to take images. So great, okay. What's happening between? You need the guider. Why? Because you're going to be guiding. You need that stability. This is complex for us, because you have this fine steering mirror. We have an attitude control system. You have to choose. Are you commanding the big mirrors? You can do that. Or are you guiding? When you are guiding you are commanding that little [fine steering] mirror. When you command that little mirror, you cannot command the big mirrors.

You have to be changing from one mode to the other. So how does this work on orbit? I'm going to come up. I'm going to move my mirrors. I'm going to stop that. I'm going to engage the guider to guide. Whilst the guider is guiding I'm going to take my image with NIRCam, so I have the stability. Once I have my image with NIRCam I'm going to stop guiding. I'm going to change sides, move my mirrors again. Then I'm going to change sides, engage the guider, command that way, take my image with NIRCam. It's this handshaking that happens all the time. We had to practice this, what could be done in parallel. Again Johnson was the first time we did this [with the flight hardware], made sure that this handshaking is happening at the right time and correctly.

What is the other thing? When I first take my images on orbit and I have 18 mirrors, each of the mirrors is going to behave by itself. When I look at 1 star I'm going to have 18 stars. My goal is to align those mirrors so those 18 stars become a single one. During this time as I'm aligning the mirrors I do need to guide. The guider cannot guide on 18 stars. You have to choose one of them. So at the beginning I'm going to tell the guider, "Hey. Here are 18 images of the same star. They're all slightly different, but I want you to choose that one. I want you to choose the one that's the equivalent of this mirror."

Even if the guider sees this image of 18 dots, we are told, "Okay, go and choose that one, please, and make sure you grab it." What I'm going to do is I'm going to let you guide on that one mirror. Then I'm going to be moving all the other 17 and align them. In the meantime you just keep guiding there. Every time I tell you, "Come in and out [of guiding] and guide there."

Once the 17 are aligned and they look quite nice I'm going to ask you, "Now guide on this, and I'm going to bring that extra mirror back here."

Depending on what they are doing with those mirrors, there are different things that we do. We have worked for all of this. Johnson was the first time where we tried a little bit of this. The rest we have to do on the simulator, because we don't have all these things. Again [that's a] challenge for us; again it's good to make sure everybody's aware for the team. For us this is a stressful time for the guider, though overall people are just thinking, "Oh, I need to move the mirror and take my NIRCam image." But the guider needs to do the in-between so you can do all of that. It's again an awareness of all your different team members and the handshaking between all the different components to make sure everything works. We have done it. I'm sure it's going to work very well, and we keep rehearsing. It's good when you have all the teams together to make sure we are addressing all the challenges from everybody and what's happening for each of them.

ROSS-NAZZAL: Sounds like an intricate dance that you have to follow.

VILA COSTAS: It is. Yes. It's an intricate dance that we will—I think we'll do it well. [That] has to be done.

ROSS-NAZZAL: Will you guys get a chance to do operations? Or once your phase is done someone else is going to pick up that effort?

VILA COSTAS: I'm lucky, I want to think it's lucky. I am lead for operations for the guider too, which is very good. I think you are trying to keep the expertise that you have from the test team in each phase that you move forward.

A few of us are part of the operations team. We will be there as support for the six to nine months [of] commissioning. I don't know if you have seen the commanding at the Space Telescope Institute. The control room for us is similar, where the commands will be sent, and then you have each of the stations. We have a room where the instrument [teams reside]. Again we have a lead for that room, which I'm one of them, I'm involved in that. I will be part of that lead for that room, but also the lead for both the guider and NIRISS with a team to make sure then that everything is happening [as needed] during that period.

The same is true for the leads for all the different components. I think that is very important, because it's one thing to know for science what you want to do. That will be once the instrument is commissioned. You have the overall scientists, and everything is going to work really well. Everything will be transparent, you are just requesting, "I want to observe this part of the sky," and it will just go. There is a huge amount of expertise on that aspect.

During this commissioning phase you are going to duplicate a lot of what we have been doing on each of the cryo tests. Things might go great. Things might not go great. You certainly want the knowledge of those of us that have worked [on the ground testing] to work at that level. Having that I think is very important, and it is in place.

What is the drawback? You have a commissioning team and an operations team and the integration that we are now working. A few of us are in both [teams]. A lot of people are not. Each of these teams are working in parallel together. For the ones that are common I think sometimes we just find it can be a lot of work because both teams are working to their goals. If you are supporting both, it's very exciting, but sometimes the workload is a bit high because their priorities don't always match.

The priority at the moment is always with the hardware. I will always prioritize being ready for launch, all the testing, the same as we did prioritize the testing at Johnson, and now the testing at Northrop, and any activities [related to this]. You keep working the commissioning ones for sure in parallel, but you want to get to the launch date. After that of course [I] get to do that. So yes, I'm very lucky. I think I'm very lucky. I'm looking forward [to it], being able to see it all the way through, that will be very exciting.

ROSS-NAZZAL: Sounds like it. When I was trying to find information about you, I noticed that you have a social media presence, that the telescope team has really promoted you and encouraged media to talk with you. Would you talk about that and the importance that you see of that effort on your part?

VILA COSTAS: Yes, sure. I think it's very important what you are doing. For any project I think it's really important to be able to communicate and share with the public to a level that they can follow and understand. I consider again myself very lucky to be able to do that. Part of it will be my knowledge, for sure. I know part of it will be being a woman, which I think is very important as well. You are [a woman] as well. I do think [women's roles] are always improving.

If we look back many years, it's always improving. I think that benefits everybody. We all look at things differently. Having diverse teams, not only male and female but of other diversity, I think is very important, because we do contribute different [views]. We look at things differently. I think you get the answers differently and better on multiple [items]. So for sure being a woman [is a reason].

I think being able to speak Spanish, so communicate in another language, is very important as well. I'm very happy to do that again because you reach people [in] different ways.

What else in my case? Being part of the Canadian contribution, and also because of my Spanish background from Spain, part of the European background, I think again that's very important as well, and great for the James Webb that it's an international collaboration. It's truly a telescope for the world. We say it truly is in the sense that everybody can request time. It is going to be difficult to get the time, but if you have a good idea in a university, send it. I think that's very important to show that it is for everybody. So I am thrilled to do it; I'm very happy to do it, both promoting JWST, promoting NASA, promoting STEAM [Science, Technology, Engineering, Art and Mathematics] for girls or boys in any way.

I'm thrilled to do it and consider myself lucky that I can, and that I can do it in a way that seems to appeal to some of the people listening. That's very good for me.

ROSS-NAZZAL: I noticed a lot of Spanish videos. I was trying to watch a few this morning, and I was unable to. I don't speak Spanish.

VILA COSTAS: I think I have an accent obviously in English, so that's always there for me. When I talk in Spanish it's a different feeling for sure, so I'm thrilled to be able to do it.

ROSS-NAZZAL: They're definitely proud of you. I noticed that you've won several awards.

VILA COSTAS: Yes.

ROSS-NAZZAL: That's very exciting to get that recognition. As you look back on this test that we did at JSC, what do you think was the biggest challenge for you as you were working through it?

VILA COSTAS: The biggest challenge, oh, I'm trying to think. I think integrating with the whole team was a challenge in the day-to-day and trying to communicate your opinion. It was a great team, so you could do it, but being able to communicate what you wanted or not—I thought that was a challenge.

The shift schedule is a challenge, that always is the case. I think I'm very familiar with that from all the previous trials at Goddard. Running the test was a challenge. It's a big chamber. It was a big piece of hardware. That portion was more complex than the one at Goddard, which was complex already.

When you are [working with] flight hardware in a chamber and you have so many contingency possibilities, that's hard. The chamber here was so much bigger. Having the expertise from Carl and Andrew [L. Francis], all the people, Jonathan [L. Homan], the ones that knew the chamber that was great. "I have this question. I'm not sure about this," and know that you could rely on them on that side. For me the chamber here was for sure a challenge.

The 24/7 is hard, and if you are leading some parts it's hard. I'm more used to that. I feel I knew the instruments well, [but] I know that was a challenge for other people. I was very comfortable with that portion just because I knew it a bit more. I think it's a mix. It's long hours for sure.

When people get tired, you always have to watch for that. I think that was a challenge as well. If people get tired it's not ideal for sure, so you have to be watching both that nothing happens that shouldn't and also the personality. We all are different when we are tired, you have to look for that. I always find we all have our own personality anyway, so in the best of circumstances you have to learn to work [keeping this in mind], but when you add stressful things [it adds an extra layer].

Some of the test results were a challenge. I'm sure the mirror team, they would have talked to you about the thermal effects [for] some of the activities, so I won't mention that, but that was a challenge. Any time you find something that you're not expecting and you know you need to fix it or you need to understand it and you have a limited amount of time and a lot of pressure, it's a challenge.

It was a lot [centered on] the mirror team. As an instrument team we had our own, but they didn't compare, I don't think, as much to that particular one that was found [on the thermal stability for the mirrors].

Of course I know the hurricane added extra challenge. Looking back, [all] went well. We were able to deal with it. At the time, trying to prepare for it, and whilst it was happening not knowing, that was a challenge. Having the team very tired was a challenge. Even after it ended you had stress, an environment that was hard for quite a few days.

As you know, being able to take the team away [afterwards]—there were planes flown specifically [to Houston]—that was really good because the teams were tired. That was very important, and I think we were all very thankful for the efforts there to bring a [replacement] team back.

I want to mention for us it was very hard during the test, and we were very worried. Of course safety of the hardware and safety of the people. Different people dealt with it in different ways—when you are in that environment that you have a hurricane, and you don't know [what might happen]. Again, I don't want to mention [names], but different personalities reacted worse or better, and we had to deal with that.

I always felt it was so hard for the people living here. Not only the people that are from Houston that have no involvement, but the people that were involved in the test but they also had their home here, all that extra worry. The ones that had to be on Center, when you have your family or your loved ones, not knowing. I think that we were thankful that most of our families were away. We didn't have that worry with all the other worries.

I think there were lots of what you call heroes. Lots of people doing lots of good work during that time. That's what it was. I think everybody did really well. That was certainly an added challenge and a challenging time to prepare and to get everything ready and to run it. Lots of good people all around doing that. We had lots of support from upper management, which is very important, on all sides. I think that again we cannot thank enough, because it's hard enough without that [support] to do your day-to-day work. That was very good.

ROSS-NAZZAL: You mentioned taking the lead on getting some work done while this was happening. You were having to deal with things like leaks and other stuff like that. I've seen the pictures with all the plastic.

VILA COSTAS: Yes. But for me it was good, because I felt it was a great contribution. In that particular case that was what I felt I could contribute. For me that helped me, that particular part came naturally to me, and it made me happy to do it. It helped me to say, "Oh yes, we can organize this. We can start doing this and get people to do that rather than just waiting and dealing with these other things." That in my case was helpful.

As I said, I think it varies for everybody. I know cases of people that were very upset, very worried, as you [could] be if you were in your hotel room. I know my hotel room, there was water falling from the windows. I remember we put towels [around them]. There was nothing the hotels could do. In my particular hotel the ground floor, the rugs were wet. You didn't know. They were rationing the food. You know how you are in the hotel, and for breakfast you can [eat] whatever. In this case we were all very aware, "Only eat what you need. Don't [take] something that you're not going to eat," because what if you couldn't get food. We didn't know how long it was going to last.

I have anecdotes. We put towels. We had to put pans in my room in particular. There was enough water [to capture]. You had to empty the pan every once in a while. I remember when I was coming to stay at Johnson, I stayed overnight, so I had to tell the hotel, "Be aware that in this room there will be nobody. Please come and empty the pans, because otherwise..." They did.

Even to bring food, I'm sure you heard we had people with pickup trucks that volunteered. I got to do the shifts to come and bring people when there was a gap in the weather, that knew when a particular place was going to have food. Again that was a challenge. Now looking back, it ended how it ended. When you are throughout, you don't know. You don't know how long it's going to be. You don't know how much food you're going to have. You don't know if it's going to get worse.

The thought of evacuation was there, and it's a big team. This had been planned before, I'm sure they would have told you. We have 150 people, easily, supporting the testing, three shifts. How do you plan for this? Do you ask them to go away? If you have to evacuate where do you find a place for that [number] of people? All of that, it was all in the background. What's going to happen, how you will do it. Different people would react different ways.

As I say, now looking back, it worked well. There were lots of anecdotes of people doing great things. Another for me poignant thing was even after it [ended], all the hotels were booked with people that had their homes flooded. In the hotel where I was, and I'm sure all of them, you had a donation [box] on the ground floor for clothes that we all had that you could put [in]. These people, they could come, that you would see here, they didn't have anything, with their kids and everything. All these things in the day-to-day that you saw that [were] so hard on a personal level for everybody. I thought that was a challenge for sure.

I know it was bad, but I think it could have been much worse, so it's good that it was as it was with the flooding. It ended, and then there was the recovery. Having your phones with the tornado warnings, that would happen at different times. I think everybody deals with this in different ways.

I think in a way those of us in Center were the lucky ones, because I think it was one of the safest places to be. Leading up to the test, we had planned, because we knew it was hurricane season. James Webb was at its safest once it was inside the chamber. The chamber was the safest place. There were plans in place, if things had happened, if anything, a hurricane, had happened whilst we were still in the clean room, to be able to roll James Webb into the chamber and keep it there.

We also joked, "There is the other chamber." We also used to say, "If needed, we can go in the other chamber."

ROSS-NAZZAL: Go into Chamber B.

VILA COSTAS: In a way being on Center was a bit more—you felt safer. With all the challenges you had to [face], I think that what people had to deal with who were outside, what would you do, and everybody's personal level of comfort. I don't want to mention [names], but I know some cases that were very very stressed, which is totally understandable. You are in a hotel, away from home, and there might be a hurricane or a tornado. It's totally understandable that you might not be comfortable. You cannot leave. There are no flights. You shouldn't drive. I think it's a personal thing as well.

ROSS-NAZZAL: How long did you stay onsite? Were you onsite for the whole hurricane?

VILA COSTAS: No, starting the night before I was onsite three nights. I think we knew after the first two days that it was moving the other way, that we had to deal [mainly] with flooding.

Then we had sleeping bags, and we had the big rooms. That was another case where being a woman did help, because I did get a room, an office, for myself.

ROSS-NAZZAL: Oh, nice.

VILA COSTAS: Which I wasn't expecting. I would have been where everybody was.

ROSS-NAZZAL: Group sleeping.

VILA COSTAS: I don't know if you know the two conference rooms downstairs. Those were filled with mattresses, but I was in one of the [other offices]. There were a few of us [on site], and I wasn't expecting it, but that was a nice thing. We have this joke, because when we tested cryo-3 we had a snowstorm at Goddard. We knew it was coming. We didn't know how bad it would be. It was a long weekend, and again we planned for that.

We had planned for it. We had sleeping bags. We had trucks. We had the people onsite to support the shift for the three days of the weekend, and I was part of that. So we joked that we had a snowstorm there and we have a hurricane at Houston, so we are waiting to see what happens at Northrop.

A funny anecdote from the one at Goddard. We had rooms with mattresses [too], and we tried to allocate some individual rooms, offices of people, that they didn't mind leaving them open for the weekend. If you are a woman— there are not many of us—perhaps you could have just one of the offices for yourself or with two women, that's maybe better.

We knew where all the mattresses were, and the first overnight which we were snowed in already, we had to distribute the rooms. I think we didn't do a good job, because I would tell you, "Oh, go to office such and such," and then some people would come back and say, "Somebody's already there." We were not good hoteliers. Then we got better. We had a list of who we had told to go to which room.

That one [at Goddard], it was a snowstorm, [which is] a bit different from a hurricane. I think the snowstorm you can plan that. You don't know how long it's going to last, but once it's on the ground [you know the extent of it]. I find the hurricane is a little bit more unpredictable until you know how it's going to develop and where it's going to go and how it's going to affect [all the areas].

The key [item] you are always looking for is loss of power, particularly if you're in the chamber. I mentioned before the gradients and the temperatures. One thing you don't want is an uncontrolled warm-up of the chamber.

We are operating at helium temperatures, so very cold. [That] is a bit more of a challenge for the team, as good as they are. If you can warm up to 80 Kelvin, and you are operating on the nitrogen, that is easier to control. That's one of the backup plans you would have. You are going to make sure in case you lose power you have still power generators to keep you [operating]. You don't want to lose power and control. Then you have to make a decision, can I leave everything powered on, the instruments, safe but powered on? Do I want to turn them off, or do I think I really need to reach that 80 Kelvin?

For JWST that would mean first warming up MIRI because MIRI is at 6 Kelvin. You need MIRI to come up to 40[K like the other instruments]. Then you need to start warming everybody at a particular rate. So you have this balance that if you do that it's going to take time, and then it will take time to cool down again. [That means more] test time, but you want to be safe. So when do you make that call to decide yes, I need to warm up?

We were lucky in both cases, both in cryo-3 for Goddard and here [at Houston] that we were able to stay [at the operating temperatures] and the decision [to warm up] was not made, [as] it was not needed. When you're planning for all of this, you're looking for all those decision points and all that knowledge through the TD. Carl, Lee, and all the supporting team, the thermal team very important, the chamber team. All of those people telling you, "This is my input." Then you have to make a decision.

Looking back, it all worked out. At that time it's a lot of things to think about. I'm sure they would have told you about how you need the chamber cool, you need helium, nitrogen, and that needs to be delivered. I know there [are] stories about [ensuring] the delivery [during the hurricane]. When you're living it [in] the moment, it's a lot of things to think about, and a lot of making sure you have all the information, and you're [working on] all the things [you need to]. In any cryo test I think that is one of the challenges. If you are at those cold temperatures how do you keep that hardware safe in all the eventualities that you can encounter?

ROSS-NAZZAL: I think it's a very interesting story about the test and how long the preparation took and all the things that went into it. I don't think people realize.

VILA COSTAS: No. I remember. It's more an anecdote. When we were at Goddard we were preparing for the weather. You always have [to do] this. If you are going to be in a chamber, it's a risky item. A lot of this preparation leading up to [a test], the year leading up to it, a lot of it is safety of both the people and the hardware, what are your protocols, how do you do, how do you safe both of them, how do you follow one path or the other. There is a lot of work going into that.

I remember one of the first meetings planning for the test at Johnson and [the local team] saying, "Well, we have to plan for a hurricane."

I remember our team thinking, "You've got to be kidding. Is this true?" It was. Because if you don't live here, [in Houston], you're not as aware [of this]. Then the way the planning went, [in particular when knowing that the test] would [happen], as [it] did, on peak hurricane season, but I remember those first meetings saying, "You've got to be kidding."

ROSS-NAZZAL: That's the last thing on your list.

VILA COSTAS: Particularly what I said before. You're going to have a huge team here. What do you do? When do you make the call? How do you make that call? "Now everybody leave." Or you tell them not to leave, and now they cannot leave. It's lots of thought that goes at different levels of management to [be prepared]. It was all very well done, I think, for our test at all levels. I think we knew at each level what we needed to provide as inputs and what to do. It was interesting, that's for sure. I have very good memories, very good anecdotes.

It was special to come back now, so thank you for this.

ROSS-NAZZAL: No, thank you for coming.

VILA COSTAS: Looking at everything [here again], and even just traveling [through] the normal places [as we did for the testing]. We were here for more than six months, it became kind of our home. Even now staying in the hotel again and doing the normal drive and remembering all the interaction here on Center, it was special for sure.

ROSS-NAZZAL: Looking back, is there one thing you'd point to as your greatest contribution to the test?

VILA COSTAS: I think I had two of them. One was what I mentioned, starting those activities when the hurricane hit. I think bringing the SI teams [on site], saying, "Yes, we need to bring them and organize them," and getting the five convoys, and then saying, "This is what we need to test." I think that helped—[and showed we could continue testing]. After that day [it was decided], "Oh, well, we can do the mirror [tests] as well." I do think that was a contribution.

The other one, the closed loop testing, I was there for the 36 hours. I know I'm not supposed to [for normal operations]. In that moment it's what you need to do, and everything was safe. I do think I was a driver for that [test] to happen, leading up to it, and then [during it,] making sure it did, and it was efficiently run. I do think those two I would highlight.

ROSS-NAZZAL: Were you up that whole time?

VILA COSTAS: Yes. I don't think—I don't know if I should—

ROSS-NAZZAL: That's okay.

VILA COSTAS: Yes, once you are running it, you feel you want it to be done within the [allocated] time. As I said, I felt it like my test. [Though] I know it's a team effort. I know it was.

ROSS-NAZZAL: But that was your baby, like you said.

VILA COSTAS: Yes. It's not a long time in [the whole] period [of the Johnson test], you know what I mean?

ROSS-NAZZAL: Oh, yes, for 110 days or however long the test was.

VILA COSTAS: Right, right. To have that one time where you are running [the test you have planned]. I think we'd all be doing the same. I can imagine if you are responsible for a deployment or a launch and it's taking whatever time, we would all do that. You can do your normal longer hours the rest of the time.

ROSS-NAZZAL: I think it's understandable. Is there anything that we haven't talked about that you think we should or wanted to talk about today?

VILA COSTAS: No, I think when you made me talk, I think of all these anecdotes. I think we have covered a lot. I think each of the SIs would tell you the things they wanted to check. I know all of them wanted for sure to confirm that everything looked good, as they did. A lot of them wanted to test with this new software, as we will operate on orbit. We did a lot of that, and that was very helpful.

NIRSpec has the microshutters. It allows [them] to take 100 spectra at a time. Those microshutters are very sensitive to acoustics and vibration, and we take that into account by adjusting the levels when we do [those tests]. I know, as we had run these acoustics and vibration together, they were also looking to get [the] information [that all was well] from a cryo [test]. They have a method. Those shutters can open and close. Some of them will fail, [and] they can fail open or closed. If they fail closed, it means you cannot open [them and vice versa if they fail open]. If a star happened to land there, you'll have a mask [so] you know which ones have failed. The ones that fail open are perhaps a bit more of a problem, because that means light is coming through that spot. You cannot close it. So the team has different methods that they [use], when they cool down, and they can take measurements to see what [their] mask is. How does it look like at the moment? How many are open? How many are closed?

They have methods to try and unstuck the ones that get stuck. For that particular team, this was one of their goals on this test. It worked out really well. They didn't have too many more that had failed. I think it was successful as well for their side.

Then the same, MIRI with the cryocooler that cools them. Though it wasn't the flight model, again they had different activities they wanted to test and measure in this chamber with the updated software. I think each SI would be able to tell you what was interesting for them for the test. Though as I said, overall the SIs just had to confirm everything was still working, the [main] goal [of the test] was on the mirrors.

The other good thing as well was [that] the SIs were used for the first time with the mirrors as they will be used on orbit. They could see how the mirror [team] will use them for their alignment and their activities. So that was I think very useful and a good, again, interaction. The mirror people could see how they have to work with the real hardware [on the instruments side], and that was good as well. [It] was a great test all around.

I'm sure all the people you talk to, each team, was really good. I do think it was a stellar effort on the teams operating and, I want to emphasize, on the chamber people here. Everybody, I think it was a great effort: contamination team, thermal team, the scripts team, the ground support. Anybody that you talk to, I think everybody learned, and everybody learned lots of things. It was very successful too.

ROSS-NAZZAL: Yes, seems like things went very well.

VILA COSTAS: [They] did. Again, when you are running them, we did have challenges. As you know, we generate these problem reports when something doesn't work, and then some of them are raised to what we call failure reports, those ones that are seen as a bit more serious. We had a couple of those.

Again, when things happen that you're not expecting, it's a challenge at the time. There was a lot of pressure. I know the mirror team I would think [had] the most pressure for their PFR [problem failure report]. That was a challenge for all of us. I'm sure they have told you how it seemed to be linked to when the instruments were [powered up], the electronic boxes, which we couldn't understand, and then they were able to isolate that there was a contact—[and then the main contributor related to the tape on the frill of the mirrors.] Different things.

Now we have a story, [a root cause], but at the time, trying to understand what's causing it, and design tests that will show it, is a big challenge. You can think, "Oh, it's probably this. I'll design this test." If it doesn't show anything you're back to, "What can it be?"

That is a challenge for everybody when you're running it. Looking back, [first] you have a [theory]. "[Does] it makes sense or not?" At the time it's a lot of effort all around to come to something [to prove it] that is safe to do with the hardware, that is timely, that won't use too much time, that will give you a good answer. What else can you be forgetting that might hide that answer? There's a lot of that going on.

The planners, I didn't mention them, but we always had the planners. On CV3 I did a lot of the planning. In this case because it was a [more] complex test we had separate planners. We provide inputs, and they adjust [activities] as they move along.

We have an optics team that simulates how the images should be and how things will come up. I always feel if I start mentioning I forget important teams, which I don't mean to at all. If you look at our shift schedule, you will see each of those [teams on shift] are key. All those people are key because you need all of them to make it run. All of them did very well.

ROSS-NAZZAL: How many people were on the science instrument team itself?

VILA COSTAS: We normally have, [on] quiet periods, two people per shift [per instrument]. When it's more interesting or more challenging—two people on shift watching the monitor then you might have two or three people doing the data analysis. I will say you will have [on the science instrument team] between, 10 to 15 at a given time [per shift] providing support.

As you know, we take a long time to cool down. When you are not powered you only need one person [per instrument] to monitor temperatures perhaps. Or maybe because this was [meant to test] the mirrors, the mirror team used a lot NIRCam and the guider, a little bit NIRSpec, a little bit MIRI. So when you were not testing specifically for those instruments, then you just need to monitor. So then you can do [it] with less people.

[Another] challenge we have with the instrument teams is the ones that have to travel from abroad. The ones from Europe—it's a challenge to travel let's say from Goddard to here, and you are within the United States [for] NIRCam. Canada as well, it's not as far. The ones that are coming from Europe, they have to deploy the team. You have to [make] a judgment call, "How many people do I think I need here? How many can I back up?"

For that you are looking at your schedule and seeing how much my instrument will be used, but also keeping in mind what if they change things and now they say, "Oh, this is not happening." Can I move it forward? That happened during the test not only for the instruments but for the cooler. "We would like to run this."

"Oh, well, we don't want to do that unless these two or three key people are here."

You are trying to always share knowledge so you have a strong team. Realistically that's not going to happen. You're going to have always two or three people that know more about certain activities or certain things. You will likely want them available or onsite. So that's something else that you do when organizing schedules. Or when you want to change, with the planners, if they said, "Could we do this?" then you would check, "Okay, I think they need this person, can that person be here? If they cannot, then how can we shift it so they can arrive and be safe."

The other thing that will come up is you might be an expert at something, and I think we are going to run what you're expert at tomorrow, so you are going to arrive, and you're here. Then you are there, and then things get delayed, so you're there and then it gets delayed a second shift and then maybe a third shift. You need to go because I need you rested.

That's why you need more than one person. You also have to keep that in mind. Things are never quite exact, and you have to know when people are good to go. I think we did very well because we do have more than one person. You always have one or two that, for a particular item, you would prefer if they are available, and you work with them not to get them tired, to have them ready. Lots of things like that that go in any planning as well that we do.

ROSS-NAZZAL: Lots of juggling of things.

VILA COSTAS: Lots of juggling, yes. It was well done between everybody. The leads did really well, Carl and Lee, as well as everybody else. As I say, I don't want to mention names, because you always feel you forget people. Truly I think everybody did very well and supported as needed, so it was a good effort. Mark [F. Voyton] did great. You need good leadership as well. Even if they're not maybe hands-on [shifts]. But you need that as well and higher up in management as well, Bill [William R. Ochs] and everybody. You need their support and their understanding and their direction when you are doing it, and I think they did a good job as well.

ROSS-NAZZAL: Thank you so much for coming in today. This was really interesting.

VILA COSTAS: You're welcome. Thank you. It's a pleasure to talk about it.

ROSS-NAZZAL: You were telling me about the complications of having foreign nationals on your team and working here.

VILA COSTAS: Correct, yes. James Webb is a science instrument, but portions of it are governed under the ITAR [International Traffic in Arms] Regulations—that has improved a lot since the time I have been working on this project. Of course a lot of the partners are foreign nationals. As I mentioned before, [there are] the two instruments from Canada and the two instruments from Europe. That has been I think a challenge throughout the program to always make [the international collaboration] better. I give kudos to NASA for always trying to make it better as different things came up.

In my case it has been a bit more so, because I became a NASA employee, so covered under different paperwork, which again they have worked really hard to do. That was also a challenge then when we were coming to Johnson at the very beginning. We have a control room but the foreign nationals shouldn't be there perhaps, that was the first thought, so they would be originally perhaps in a different building. We were indicating that's not a good way to work because you need the day-to-day [interactions], so the effort was made to have the adjacent control room where the foreign nationals would be, basically [where] the SI instruments would be hosted.

Unfortunately NIRCam is the only instrument that's not a foreign national [team], but they [are] together with [the rest of the instruments], so we were all there. [This] was worked at the beginning when we started planning the test. The [foreign nationals] couldn't come into the main control room, that was the original rule in case there was sensitive information discussed—though those are general words, but you never quite know what this meant, because nobody has any interest apart from making sure [their] instrument works.

[By the time we started] the test, they were allowed. There was, I'm sure, lots of paperwork. That was another big team effort where we had different badges, where we were allowed to be unescorted. That's another challenge if you have to be escorting foreign nationals on three-day shifts for months on end. That has worked well, and I think it's worked every time.

We have the challenge now in Los Angeles with Northrop Grumman. We had it before at Goddard, and every time we have to work it. I'm sure that's something to keep in mind as well.

ROSS-NAZZAL: Sure. Were they sympathetic to that, or did they feel put out by the fact that they had been working on this and now they were being excluded?

VILA COSTAS: I think talking as [part of] their team, it always feels a bit strange because it's difficult [to be excluded]. The concept is understandable. We have controls. At the same time, [as] each of us, they're just trying to do their work. They are only interested in their instrument and what they [need] to do. So sometimes it does feel a little bit that if we are a team we should be a team. [The rules are] understood, so [everybody] abides by what is needed. But it's a challenge.

ROSS-NAZZAL: That's interesting. No one has mentioned that before.

VILA COSTAS: Yes. In my case, I guess being at NASA, the NASA team has done incredible things for me. In this respect it has been a lot of work to get [paperwork] up to speed, always abiding by the rules. It started at Goddard. If I have the expertise to be a test conductor or a test director but I cannot because I'm a foreign national, just because of that label, it doesn't make sense. You lose a lot of expertise that you need. So it's getting all the paperwork in place.

It continues as I say, [at] Northrop, perhaps even more so at Northrop. No foreign national is allowed unescorted anywhere yet. At least in Johnson we were able to.

ROSS-NAZZAL: Yes, you could bring them onsite at least.

VILA COSTAS: At Johnson the foreign nationals, once we were cleared we could come and go with our proper badges as a normal employee, which was great. We are still working that for Northrop.

ROSS-NAZZAL: That's important to know as space becomes more international in scope, because projects are so expensive, this is probably going to happen more and more.

VILA COSTAS: I think so. Yes, it's good to know. I think it is very important to have international collaborations. I think that's the way of the future for many projects as you indicate. I think it's important to have that and truly identify what is the ITAR [portion] and what is normal work that can be controlled [which would] allow [easier collaborations].

ROSS-NAZZAL: Thank you.

VILA COSTAS: You're welcome.

[End of interview]