NASA STS Recordation Oral History Project
Edited Oral History Transcript

Tony Bartolone
Interviewed by Jennifer Ross-Nazzal
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Ross-Nazzal: Today is July 5, 2011. This telephone oral history with Tony Bartolone is being conducted in Houston, Texas, and at the Kennedy Space Center [KSC] in Florida for the STS Recordation Oral History Project. Jennifer Ross-Nazzal is the interviewer, assisted by Sandra Johnson.

Thanks so much for joining me this morning. I certainly appreciate it. In 2005 you became the lead External Tank [ET]/Solid Rocket Booster [SRB] project engineer. That's a mouthful. Tell us about your job.

Bartolone: Being the lead ET and SRB project engineer, it's kind of an interesting job. It's actually rather difficult to describe, but I think the best way that I've learned to describe it is that I'm essentially a liaison between the Ground Processing Directorate here at Kennedy Space Center and the various design and manufacturing centers where the ET/SRB and RSRMs [Reusable Solid Rocket Motors] are designed and sustaining engineer occurs and also built.

So I serve as kind of like a go-between from all aspects of the processing of those elements, beginning with their element acceptance reviews when the hardware is ready to be shipped from the manufacturing sites, all the way through launch countdown. That is sort of a little nebulous description that involves all kinds of different activities related to the actual delivery, the receiving inspections, overseeing any type of technical problems that arise during the processing of those elements here, and then communicating and integrating any of those problems back through the design centers and the appropriate engineers at those locations that are responsible for the sustaining engineering, and trying to come to a resolution on them, obviously as efficiently and as delicately as possible so that we don't have any major impacts to the milestones here at the processing center.

ROSS-NAZZAL: That sounds like a lot of work, actually.

BARTOLONE: Yes, it's definitely one of those things that every day's a little different. It's exciting. I've got to tell you, of the jobs that I've had, this is by far my favorite.

ROSS-NAZZAL: Tell us, when you were selected in 2005, how you basically came up to speed on all of these things, because what you're talking about seems to be so detail oriented that you would have to get up to speed in some way. How did you end up doing that? Did you shadow someone, or is there a book?

BARTOLONE: I was mentored by the person that was the lead project engineer prior to me, Greg [S.] Breznik. He had since moved on to become a branch manager here at Kennedy Space Center, but he brought me in. He taught me everything that he knew about it, and obviously he admitted that there were going to be some gaps and kind of learn as you go. Fortunately, this office, the project office that I work for here at Kennedy Space Center, had a very vigorous training program, certification program, to become what they call Level-One-certified. That entailed an awful lot of classroom work, online instruction, and a lot of on-the-job training, observing various operations to make sure that I was not only familiar with the processes and the technical aspects of what's involved in getting these pieces of hardware ready for launch, but also the people that were involved, because, in all honesty, a lot of my job revolves around actually knowing who the right people are in order to get a problem solved and being able to pull those people together when needed and to have earned their respect to come in and lead them through a challenge. It was a lot of on-the-job-type training, I guess you could say, that I had to go through in order to earn that respect.

ROSS-NAZZAL: Would you tell us about some of the processes that you inherited that you saw maybe that needed to be changed or evolved over time? Were there any?

BARTOLONE: Well, Shuttle, when I came in, was obviously a very mature program. There were some things that we did tend to evolve, especially in the Return to Flight timeframe, when I started here external tank was at the heart of the *Columbia* tragedy [STS-107], the loss of foam that caused us to lose *Columbia*. That, in and of itself, changed the mentality. It really, honestly, changed the approach to external tank, the engineers that worked on it, and all the aspects associated with getting the tank ready for launch. I think a lot of that transition happened just around the time I actually was coming in the door here, so we continued to tweak that.

We've had, obviously, some rather significant external tank problems through the last five years, six years, that have caused rather significant launch delays. Each time we've gotten better and better, but it's been a challenge. The phrase, honestly, that we use is that the external tank team feels a little bit like a dog that's been kicked a little too much. We've gotten to the point where we've become the butt of the joke some of the time, but we've become resilient to the fact that no matter what, we're going to get things done and we're going to get them done right. In a way, I'm very proud to have been part of that team to help us overcome a lot of these things, because the Shuttle wouldn't launch without an external tank. We are the backbone of the vehicle. Without us there is no launch. I think some of the folks that seem to look at us as a liability have come to respect us as being a very integral part of the Shuttle team, so it's been quite a roller-coaster ride the last few years.

ROSS-NAZZAL: Yes, I can imagine. And how exciting for you to be involved in 2005 with the Return to Flight. That must have been a major challenge. For instance, *Discovery* was actually rolled back to the VAB [Vehicle Assembly Building].

BARTOLONE: Yes.

ROSS-NAZZAL: Can you talk about that some, to swap out that external tank and the challenges that that posed?

BARTOLONE: Yes. After overcoming everything that was involved with the foam losses and the modifications that we had to do to make foam shedding less of a concern for the vehicle during launch, then we got hit immediately there before we were even able to get off the launch pad, with the next major external tank problem. That was with the ECO sensors (the engine cutoff sensors), the electrical component in the hydrogen tank that is used to sense when we're about to run out of hydrogen so that the main engines in the Orbiter will shut down without causing catastrophic damage. If the engines were to run what we call LOX rich, or liquid oxygen rich, they could overheat and you could cause the turbopumps to explode. Obviously these sensors are extremely important. They're a backup system. The primary system is based off of the propellant-consumption calculations that the Orbiter computers do during ascent. In the event that those computers somehow miscalculate, these sensors are designed to kick in in that emergency situation and prevent the vehicle from experiencing a catastrophic failure.

So, obviously, the mission management team and the senior program managers weren't going to let us launch without getting that issue resolved, and that entailed bringing that stack with *Discovery* on it back to the VAB, like you said, and we had to swap *Discovery* to another stack, to another external tank that was waiting for actually [what] would have been the subsequent mission, which was STS-121. We took that stack, went back to the pad, and were able to get through a tanking test demonstrating that those sensors on that tank were working fine. And then we took the tank that had the electrical problem with the ECO sensors and actually ultimately de-mated it from the SRBs and sent it back to Michoud Assembly Facility in New Orleans [Louisiana] where the tanks are built, for the manufacturing folks to troubleshoot it.

ROSS-NAZZAL: How long did all of that take?

BARTOLONE: Well, ET-120 didn't return to Kennedy Space Center for two years after that. It ended up going back to Michoud, but as you know, Hurricane Katrina struck that summer in 2005, and so it got lost in the shuffle out there with all the facility damage and the workforce issues that Lockheed Martin experienced as a result of Hurricane Katrina.

Ultimately it was able to be resolved and upgraded and returned here to Kennedy Space Center, only to have another issue with the ECO sensors come up, not on that particular tank, but on a third tank that we ended up having to go and troubleshoot throughout the holidays of 2008. That one, ECO sensors again kept us on the ground, kept us from launching, and we ultimately had to go and figure out why this problem was happening. Lockheed Martin simply went into the tank, ET-120, and subsequent ones, replaced the ECO sensors, thinking that that was going to resolve the issue, but the ultimate determination in terms of what was causing that problem turned out to be that there was a connector that went through the wall of the hydrogen tank that had some contamination in it.

As a normal set of processing, these connectors are greased with something called Krytox grease, and that's just to allow the connector to be installed and allow that electrical connection to happen through the wall of the external tank without having obviously any sort of leak in that area. That connector actually is a set of pins that are embedded in glass, and what was happening is that some of the Krytox lubricant that was used to allow the connector to be mated was actually getting onto the pins of those connectors, and under cryogenic conditions, the Krytox grease was actually creating an open circuit. It wasn't allowing the pin to seat in the socket and allowing the electrical connection to go through.

We were interpreting that as being a loss of the signal or failure of the sensors onboard the external tank because of the open circuit. We ended up actually having to take that connector out of that tank that gave us the problem in the winter of 2008, and then subsequent tanks thereafter, and ended up actually welding or soldering those pins to their sockets to prevent contamination from creating an open circuit. From that point on, the ECO sensors problem was resolved, and we never had a recurrence of it.

ROSS-NAZZAL: Was that tank finally used then, ET-120?

BARTOLONE: Yes, yes, it was. ET-120 ultimately did fly and flew very successfully, actually.

ROSS-NAZZAL: Tell us about a more recent mission, which was STS-133, which also had problems with the tank, pretty significant problems.

BARTOLONE: Yes. STS-133, back in November of 2010, we had made a launch attempt with *Discovery* on ET-137. During that first launch attempt on—I think it was November the fifth, we actually encountered a hydrogen leak again at the ground umbilical carrier plate, or what we call the GUCP, and that hydrogen leak was the third recurrence of that hydrogen leak since Return to Flight. And that anomaly actually caused the scrub for the day. During the process of de-tanking and draining the external tank as a result of the hydrogen leak at the GUCP, our ET engineers, what we call the ice team, the folks who do the final inspection of the external tank, saw from their camera views that the flange on the liquid oxygen tank at the top of the inter-tank had actually cracked. You could see that there was an offset in the foam that covered that flange. That was very alarming, because that indicated structural problem underneath with the aluminum that makes up the inter-tank. We had never seen anything like that before, so that kicked off an immediate investigation.

In parallel with the resolution of the GUCP leak, the Lockheed Martin team and the External Tank Project up at Marshall Space Flight Center [Huntsville, Alabama] began investigation of why that failure occurred. We ended up having to go and remove the foam out at the launch pad on these stringers that we saw that had cracked. We uncovered that there was a series of actual parallel cracks that went down from fastener hole to fastener hole on about the top nine inches of two of the stringers, and that had caused them to almost buckle. They had come away from the skin of the external tank, and that was what caused the offset in the foam that we were able to visually detect. That resolution actually was a rather lengthy one. As you know, we didn't launch STS-133 successfully until February.

So, again, throughout another holiday period, we had to go and do some rather extensive work. We managed to go and do an instrumented and tanking test right before the Christmas holiday in 2010 and got some very useful data off of the external tank and tried to learn what the stresses were. Then obviously the metallurgy of the external tank came into question. The stringer material, that aluminum 2090, a very specific type of aluminum that's manufactured by Alcoa for Lockheed Martin to support the Space Shuttle Program, was determined to actually have some characteristics under cryogenic temperatures that were less than ideal. Although they met the procurement spec [specification] for Lockheed Martin, for the external tank for Shuttle, there were fracture toughness qualities about them that made them a little less than what we had normally seen for external tank production, and that was ultimately deemed the root cause of this, the stringer crack failures that we had seen.

And, actually, throughout that process we ended up rolling back to the VAB and implementing what we called a radius block mod [modification], which is basically just a structural doubler that was installed on the top, over the top of the first nine fasteners at the top of these stringers all the way around the external tank. A total of 108 stringers were modified to include this radius block modification, and that gave us the structural strength, even with the questionable material, to allow the tank to be cleared for flight. Ultimately we were able to launch in February without any issues. The tank structure was perfect. It did a great job with us for getting *Discovery* on her last voyage.

ROSS-NAZZAL: You mentioned some of the tests that you did, the tanking test. Were there other tests that had to be conducted before you could sign off and say that this tank is flight-ready?

BARTOLONE: Absolutely, yes. We did a series of nondestructive evaluation x-rays looking for any type of micro cracks that could have existed inside of the parent metal. Photogrammetry was the other test that we did and that involved placing a series of dots on the external tank's inter-tank. We measured during the tanking test the actual stresses via 3D cameras that were developing as the tank would shrink as a result of the liquid oxygen being loaded into the LO2 tank on the top of the ET. That gave us quite a bit of data to ground the computer models that we were using for stress analysis and things of that nature to get us comfortable that the radius block mod that we were going to go and implement and ultimately did implement was going to give us the structural strength that we needed to be able to confidently launch STS-133.

ROSS-NAZZAL: Do you conduct these tank tests at KSC or do you do them at Marshall?

BARTOLONE: The tanking test itself can only be done at the launch pad where we can actually load it with the propellants, but an awful lot of testing related to the investigation for the stringer cracks was conducted both at Marshall and at the Michoud Assembly Facility out in New Orleans. Those are the locations that obviously have the design responsibility for the external tank and the manufacturing responsibility, and that's where the experts are in terms of the structure of the external tank. But, obviously, you know, there's only some unique capability that you can only do at the launch pad, and that's where the tanking tests really came into being one of the major indicators of whether or not the tank was going to be capable of launching or not, because if we went and did this radius block mod and then loaded it again and saw another failure of this type, this tank more than likely would have been discarded.

ROSS-NAZZAL: How do you test the external tank on the launch pad? Is it isolated by itself? Is it attached to the SRBs? How does that work?

BARTOLONE: Well, yes, it's mounted to the SRBs, and the Orbiter actually is attached to the external tank, so it's an integrated system, but the tank's major function is to serve essentially as a giant thermos. We load it with liquid hydrogen and liquid oxygen, and its sole function is to feed the main engines on the Orbiter during ascent. The largest focus of the external tank's purpose is fuel storage and fuel transfer to the Orbiter. So when we do a tanking test, we're basically full-up testing all the systems on the external tank, the valves, the actual structure, how it performs under the stresses of the minus-423 hydrogen and minus-273-degree oxygen, all of the various electrical systems, the heaters that are on that tank, making sure that all of the things were within our launch criteria limits.

It turns out that in the instrumented tanking test realm, we were able to learn a little bit more about the actual underlying structure. You have to keep in mind that the external tank was originally designed in the 1970s, although there were iterations to go through modifying the tank and actually reduce its weight to allow us to build the Space Station. Ultimately, its structure has not really changed very much. The different materials that are used to manufacture it have changed somewhat through the years, but it was designed on paper back in the 1970s. These models that were created as computers came into existence in the eighties and nineties were relied on more heavily for the engineering tests of some of this hardware. We created a lot of these computer models to simulate how the stresses and how the structure of the external tank was put together, but they were never validated with any test data, and actually it turned out that STS-133 was able to give us some very good test data that confirmed that our model assumptions and our inputs that we had done to these various computer models that simulate the structure of the ET were correct. So that was very reassuring, and that actually led us to gain a lot of confidence in the fact that we were able to go do this modification and get the structural strength back that we needed to allow us to launch.

ROSS-NAZZAL: Tell me, if you would, did you ever face any pressure from the Shuttle Program Office or from [NASA] Headquarters [Washington, DC] to find that solution?

BARTOLONE: There was, I would say, some delicate pressure. Obviously, being the source of the launch delay, the program is obviously wanting to make sure that resolution is achieved, whether it's the external tank, SRBs, or the Orbiter, with all due diligence and all due speed. But they were more concerned about the resources available, because getting close to the end of the program at that time and now here we are at the end of it, the engineering talents that Lockheed Martin had at Michoud at the Assembly Facility, and the External Tank Project had up at Marshall was diminishing. The experts were getting fewer and far between, and so they wanted to make sure we had all the right people to be able to execute the task that we needed to go do.

It turned out that a good number of folks actually ended up having to be recalled that had been either placed in other places in Lockheed Martin or let go in order to allow us to do this, and some of the delay that we experienced was associated with a little bit of that. But I wouldn't say that there was pressure so much from the program as there was concern that we were going to actually be able to have the resources necessary to overcome it.

ROSS-NAZZAL: There was another issue that I had seen about that flight in particular. There were some problems mating *Discovery* to the external tank on STS-133. Can you talk about that some?

BARTOLONE: Yes, there were a couple of minor issues, actually. We had an issue with the turnbuckle that's used to draw the Orbiter in during the mating process to the external tank as the Orbiter's hanging from the overhead crane in the VAB. Then once we were actually able to get the vehicle mated and resolve that issue, we had a problem with the pyro-can installation inside the aft compartment of OV-103 [Orbiter Vehicle-103, also known as *Discovery*]. The pyro can that's used to cover where the explosive bolts are that separate the external tank from the Orbiter, once we've reached main engine cutoff in orbit, getting that pyro can installed was a little bit tricky. There were some alignment issues. We were able to overcome those, but that did cause a couple days' delay during the Orbiter mate process, but nothing too significant. That obviously all occurred well before we had the hydrogen leak and the stringer crack that happened back last fall before we rolled out to make our first launch attempt on November fifth.

ROSS-NAZZAL: I did want to go back and ask you a bit about the Return to Flight. Were there any challenges that you faced in terms of vehicle integration working in the VAB? Because obviously there had been some changes to the external tank when she rolled in.

BARTOLONE: Yes, there had been. There were actually a few challenges, but at the time that all was going on, I was coming up to speed with training. Some of the issues that I do recall from back to the Return to Flight timeframe were actually the lack of space that we had. We had a couple tanks in storage in the VAB. We had two stacks that had been integrated prior to actually my arriving here. One was the STS-114 stack, and one was the STS-121 stack. We ended up swapping, as you talked about before, with ET-120, swapping *Discovery* from one stack to the other in order to get the STS-114 launch off the ground in 2005.

We were space-limited in a way, but we had some kind of growing pains, I guess you could say, from getting the program back up on its feet. It had been several years since we had processed and gotten ready for a launch. There had been some attrition from the workforce and some of the processes had become a little bit, I guess, stale, I guess you could say, because we hadn't run them in so long that it took folks a little bit of time to get back into their groove and get a vehicle stacked and ready to go out to the launch pad.

But overall, it was actually an amazing time to be here, to see the VAB and to see the Kennedy Space Center as a whole come back to life in a way, after having stood down for that accident investigation when we lost *Columbia*. It was really a thrilling time to actually see us getting hardware ready, and to just see the morale improvement that happened here was just phenomenal to see, because a lot of us, if not all of us here, we're driven by launches. We get a thrill from seeing the vehicle clear the tower on launch day, and that flame is what drives us to get the next vehicle ready. That actually is one of my main concerns here. We have this last launch here at the end of the week. That flame's going to get extinguished.

ROSS-NAZZAL: Yes, it's a really sad moment for so many people, especially at KSC and JSC [Johnson Space Center, Houston, Texas], all the Human Space Flight Centers.

BARTOLONE: Yes.

ROSS-NAZZAL: I wanted to turn now, if we could, to talk about the integration processes, if you could walk us through how an ET arrives from Louisiana, how it's transported to the VAB, how long that process takes.

BARTOLONE: Well, external tanks, like I mentioned before, are built at the Michoud Assembly Facility, or what we call MAF, out in New Orleans, Louisiana. When a tank is ready for delivery, we dispatch one of our SRB retrieval ships, either *Liberty Star* or *Freedom Star*, and the ET transport barge named *Pegasus*. The ship and the barge will go out to the Michoud Assembly Facility. They'll roll the external tank on its transporter out to the barge and load it onto the barge and secure it for the ocean transport across the Gulf of Mexico and then up the east coast of Florida to the Kennedy Space Center. That trip generally takes about seven to ten days for the tank to arrive here, from the time it leaves the factory in New Orleans, transits through the Mississippi River out to the Gulf and then across the Gulf and then up through the Straits of Florida and then up to Cape Canaveral.

Then once it arrives at Cape Canaveral, it goes through the port and comes up the Banana River to the turn basin right outside the Vehicle Assembly Building. The barge is docked there. We have a slip where we secure the barge and then we take the tank off of the barge. That whole process takes about four hours from the time that the barge is secured and the doors are opened to when the transporter's powered up and the external tank is rolled off the barge. It's maybe, I don't know, about a thousand feet or so from the barge to the doors of the VAB, but obviously it's a slow process and we take everything very carefully because it's a very expensive and unique piece of hardware. We don't want to, obviously, do any damage on the last few feet of its journey.

There's been some instances where we have not used an SRB ship and had to charter oceangoing tugs to pull the barge because of other operations that the booster ships are engaged in that don't allow us to use them at the time, but, overall, that's pretty much the process of getting a tank here to the VAB from New Orleans.

ROSS-NAZZAL: Is she inspected once she gets into the VAB?

BARTOLONE: Absolutely. Actually we do a preliminary inspection with it on the barge on the areas that are visible there just from walkup. Once it arrives in the Vehicle Assembly Building, it's taken off of its transporter and rotated to the vertical, and then it's lifted up into one of four checkout cells that we have in the west side of the VAB. Once it's up and over the top of those checkout cells, there's a crane that's lowering it down past the initial set of platforms that's in the checkout cell. We have a team of engineers and technicians and quality inspectors; they're visually inspecting the tank as it passes them by, so that they can see any anomalies, anything that could be visually detectable in the foam or the structure of the tank as it's being lowered into the checkout cell where we do the first stage of processing on the ET, getting it ready to mate to the SRBs.

ROSS-NAZZAL: Are there any other sort of inspections that it undergoes, or it's just a visual inspection at this point?

BARTOLONE: Well, the first inspection is visual. Then once it's in the external tank checkout cell, we do do a series of operations on it. We do electrical checkout [called "all systems checks."] We test the various systems on the ET, make sure that they're functioning, and also pneumatics checkout on it to make sure that the valves are functioning properly.

Then Boeing actually comes in with a team of folks from California, because the umbilicals that are on the bottom end of the external tank are actually built by Boeing as matched sets to the Orbiters. Boeing is responsible for the actual design and manufacturing of that particular piece of hardware, even though it's integrated onto the external tank at Lockheed Martin's facility in New Orleans. They come in and do a series of what we call angle and tip load, which is where they balance out the valve plates that are on the seventeen-inch feed lines that feed the liquid oxygen, liquid hydrogen into the Orbiter. They adjust them, make sure that there's no corrosion present. They do any repairs necessary to them to get them back within compliance or specification for the vehicle that they're going to be mated to, and they go about clearing those and getting them prepped for Orbiter mate.

So there's a variety of different things that go on with the external tanks once it's in the checkout cell, and a lot of those are those ones that I just described to you, and then, obviously, any visual anomalies or any foam issues that we detect from the actual receiving inspection are also addressed in the checkout cell. Any foam repairs, any type of different materials that need to be either replaced or sanded to return them to conform with the aerodynamic requirements for the external tank, those are all done in the checkout cell if we can accomplish them.

ROSS-NAZZAL: How long is the external tank generally at the VAB until the SRBs arrive?

BARTOLONE: Well, since Return to Flight actually, external tank up until, I think, the last eighteen months or so, the ETs had been arriving just in the nick of time. Each one would come in and the SRBs would already be stacked ready and waiting for it.

The SRBs, they're a story in and of themselves, in terms of how that hardware is delivered and processed, but generally from the time that a tank would arrive in the VAB to the time that it was mated to the SRBs is on the order of sixteen to twenty-one days, and we've actually done it as short as fourteen days on one flow since Return to Flight. Then once it's mated to the SRBs, it spends about another two weeks mated to the SRBs as we do the integrated closeouts and get the ETs secured to the SRBs and all the various processing that needs to happen there, getting ready for Orbiter mate, which would happen, again, after that two-week period. So from the time that a tank would arrive from getting off its barge to the time that it's mated to its SRB and ready for ready for an Orbiter to mate, it's somewhere on the order of about one month.

ROSS-NAZZAL: You mentioned that the SRB processing was a different story. Can you tell us a little bit about that?

BARTOLONE: Yes, absolutely. Well, the SRBs are made up of two components, and they're provided by two different manufacturers. The solid rocket boosters, their main component is what we call the reusable solid rocket motor, and that is made up of four segments, both lefthand and right-hand side, so a total of eight segments makes up an SRB stack for a Shuttle launch.

Those segments are actually manufactured and refurbished by ATK [Alliant Techsystems, Inc.] out in Promontory, Utah. Those come in via railcar at a specified delivery date to support the different milestones for the various missions in the Shuttle Program, and they arrive here usually somewhere in the neighborhood of about six to nine months prior to their scheduled launch date. They are received at what we call the Rotational Processing and Surge Facilities (RPSF). The railcar covers are removed, and they're taken off of their railcars and rotated to vertical, similar to the external tank. They're placed on a series of steel pallets that are designated for each individual segment, so that when it comes time to actually stack the SRBs, we can pull them out of the storage location in the proper order so that we stack them obviously in the correct orientation.

Then the aft skirt, which is what actually supports the entire weight of the Shuttle vehicle on the launch pad, and then the forward skirt, or what we call the pointy piece, where the various avionics and electronics boxes for the SRBs are located, as well as the parachutes that allow us to reuse the solid rocket boosters and go and retrieve them out in the Atlantic Ocean, those come from the Assembly and Refurbishment Facility which is run by United Space Alliance, actually, just down the load here from where the VAB is located on Kennedy Space Center. But that facility is actually owned and operated by the Marshall Space Flight Center. So just like external tank, the Marshall Space Flight Center has design responsibility and sustaining engineering responsibility for RSRM and SRB. Even though the forward and aft skirts are refurbished and assembled and checked out here on Kennedy Space Center property, that facility and that process is overseen by Marshall until such time that the forward and aft skirts are transferred to ground ops [operations], to Kennedy Space Center's Processing Directorate. So it's a little bit of a different makeup of the SRBs and how those various pieces and components get brought together.

Thankfully, since Return to Flight, that whole process has been very smooth. The SRB Project in both ATK in Utah as well as the SRB Assembly and Refurbishment Facility here has been virtually flawless in their execution of getting their hardware ready and delivered to us. Thankfully so, because with the challenges we face with external tank, that was one of the things that was kind of very nice to rely on, the fact that they had everything, all their ducks in a row pretty much for the last five, six years.

ROSS-NAZZAL: When I was doing some research, I didn't really find anything about those elements. It seemed to all focus on the external tank.

BARTOLONE: Yes, external tank has definitely been the celebrity the last five, six years.

ROSS-NAZZAL: I like that. That's a good phrase.

Tell us about mating the SRBs to the external tank, if you can just sort of walk us through that process.

BARTOLONE: Sure. Well, the first part of the SRB process is we mate the aft motor segment to the aft skirt, and that happens in the RPSF, the Rotational Processing and Surge Facility here at Kennedy Space Center, and then once that's done, we call that the aft booster assembly, because it's now a motor segment, and an aft skirt is transferred to the VAB, and we stack those onto the mobile launch platform that's going to be used for that mission.

Then we go through the rest of the stacking of the Lego pieces, essentially all the different motor segments that make up the remaining of the SRBs. Once the SRBs are fully stacked and the structure installed and they're ready to receive the external tank, the ET will come out of its checkout cell, be lifted by a very large overhead crane in the Vehicle Assembly Building and transferred across the transfer aisle into the integration cell, where we lower it down and mate it to the solid rocket boosters. We attach the various structural members that hold the external tank to the solid rocket boosters. At that point, the ET is being fully supported by the two solid rocket boosters that are there on the launch platform.

Then we do a various set of closeouts where we go and make electrical connections and do integrated tests to make sure that the wires that run through the ET and into the SRB has got good continuity, there's no issues with any of the communications and various electronics boxes that are on the SRBs. We've got the integrated stack ready to mate with the Orbiter vehicle that will be brought in for that mission.

ROSS-NAZZAL: When is the Orbiter finally brought in?

BARTOLONE: The Orbiter is finally brought in somewhere in the four- to six-week timeframe from when SRB stacking has started, after ET mate is done, and then the Orbiter is rolled in on an Orbiter transporter into the VAB and then lifted off this transporter and rotated to vertical, and then, just like the external tank, lowered down to the integration cell, and a series of processes goes on where we go through soft mate and a hard mate to get the various different bolts and fasteners installed to secure the Orbiter to the side of the external tank.

ROSS-NAZZAL: What's the difference between a soft mate and a hard mate?

BARTOLONE: Soft mate is where we've got the vehicle suspended from the overhead crane. Only a subset of the various fasteners that are required are installed, but it's secure enough to allow the Orbiter-handling folks to go into the aft compartment of the Orbiter and do the process that involves the turnbuckle, which is essentially the jackscrew that draws the Orbiter into the mating surfaces of the external tank with those people in the aft compartment. Once the Orbiter is fully jacked into position and secured onto the vault fitting to the external tank, then we install the remaining fasteners, and that's when we declare hard mate. At that point, the vehicle, the Orbiter, is being fully supported off of the external tank. The sling that lifted the Orbiter into the integration cell can then be detached, and the vehicle standing on its own supported by its attachment to the external tank and then ultimately through the solid rocket booster attachments down into the mobile launch platform to the hold-down posts.

ROSS-NAZZAL: How long does that whole process take?

BARTOLONE: The Orbiter-mate process is on the order of about three days to go from vehicle roll-in to soft mate to hard mate.

ROSS-NAZZAL: Is that an operation that runs twenty-four hours a day?

BARTOLONE: Yes it is. The majority of our operations here, especially in critical milestones where we're doing hardware integration like SRB stacking, ET mate, Orbiter mate, they're twenty-four hours a day.

ROSS-NAZZAL: How do you keep up with that? Do you work eight hours a day or do you work longer hours?

BARTOLONE: Oh, no, much longer hours, unfortunately. That was one of the things about this job that I think probably a lot of folks shied away from, but I actually kind of leapt at the opportunity. It definitely requires some very good flexibility and the ability to put in rather long days. I think my average day is somewhat in the order of about ten to eleven hours a day.

ROSS-NAZZAL: How do you keep up with any sort of engineering or technical problems that might pop up?

BARTOLONE: Well, through my relationships with the various system engineers that work on the subcomponents of the external tank and solid rocket boosters, we have a network of communications and various log systems that they put notes into or emails, telephone calls. It's a constant process of keeping communications going. Typically, if I haven't heard from a particular system or group, I'll go and I'll go sit down with them face to face and talk with them, "How are things going?" Just to keep up a good rapport with them and remind them that any issues that they're encountering or anything that they may think is a minor issue, to keep me involved or in the loop on it so that I can make sure that the design centers and the manufacturing locations are aware of any technical issues we may be having here, and any assistance that they could potentially offer us to either avoid a larger issue when a minor issue comes up or to resolve some of the major issues. So that that whole process, I guess that continuous loop, can function so that we can keep things kind of going at an even and sustainable pace.

ROSS-NAZZAL: What do you think has been your biggest challenge since starting the job in terms of technical or engineering complications?

BARTOLONE: Well, you know, there's been a lot of different things that I guess I consider challenging, but to me, honestly, the biggest challenge has been to earn the respect of the engineers that work on my flight elements. A lot of these folks are very seasoned engineers that are very specialized in one system or another, but they don't necessarily see the big picture and see how maybe a problem on their system could affect either another system that's also on their flight element or even a system that's not even related or on their flight element, and I help them make sure that they see a little bit of the bigger picture and that we don't run into a problem.

Let me give you an example. If there's an electrical problem with one of the avionics boxes on a solid rocket booster, well, the electrical engineers that are responsible for that particular component may see it as just a local problem that they need to go and resolve, but they don't see the larger picture of the fact that if that issue or problem is not necessarily an isolated problem, it could probably have a downstream effect on the computers in the Orbiter, the electrical wiring that's in the external tank. There's various different facets of it that they may not be necessarily so in tune with because they're very specialized to that particular system. But there is more of a kind of global type of approach to making sure that we integrate things that seem like they're a local failure but could potentially have an overarching kind of global type of implication, and that's where the project engineer like myself would get involved.

ROSS-NAZZAL: You've walked us through the whole process of mating the vehicle in the VAB. What do you have to do to finally release the vehicle from the Assembly Building? Is there some sort of check that you have to do that says this vehicle has been certified, it's ready to go be put on the crawler?

BARTOLONE: Yes, absolutely. We have a process here called the S0008, which is just a nomenclature for a set of procedures that we do, and it's the first actually powered-up integrated testing of the entire vehicle as one stack. Essentially when the Orbiter is finally mated and it's ready, all of its electrical connectors are done and all the mechanical fasteners are installed and all the closeouts that are necessary to be done on the VAB prior to going on the launch pad are complete, we do a full-up integrated vehicle power-up. We test all the different systems onboard the vehicle, on the SRB, the external tank, and the Orbiter, make sure that all of them are communicating each other, that there's no issues with any of the function of any of those systems.

Then, obviously, there's the visual aspect of making sure that all of the various closeouts and processing and any defect or repairs that need to be completed are done prior to allowing us to retract the platform in the Vehicle Assembly Building to get the mobile launch platform and the stack ready to go out to the launch pad. Only once all of that is done and the vehicle is verified ready to go to the next stage in its processing out to the launch pad, will we allow the crawler to come in, pick up the stack, and take it out there.

ROSS-NAZZAL: I read that you monitor the vehicle all the way through launch countdown. What does that entail?

BARTOLONE: Well, once the vehicle is at the launch pad, my job function actually changes a little bit, and we begin doing a lot of this integrated testing in the firing room. Up to the time where we do what I just talked about with S0008, with the ET and SRB, there's no power-on testing. It's all local testing done with various different small electronics, ground support equipment boxes that are in the VAB.

But once we go into S0008 and then subsequently out to the launch pad, all of our integrated testing and activities are run out of the firing room in the launch control center [LCC]. At that point, we begin staffing up for various different integrated tests in the LCC, in the firing room. My job responsibility transitions from more of an office kind of function, office and processing facility, back and forth with the VAB or the RPSF, where my components are going through their stages of development or integration, then to the integrated vehicle out at the launch pad where I then transition to support the integration console, which is in the firing room doing a kind of—I guess maybe the closest analogy I could give you would be a little bit like an air traffic controller, where you're sitting at a series of computers monitoring various different systems, listening to the different communications going on on the headset that you're wearing, and the different systems that are doing their different tests and making sure what they're doing isn't going to impact what another system is testing. [It] becomes a lot more of a fast-paced kind of environment than the processing world is, if you can believe that.

ROSS-NAZZAL: Do you have any involvement whatsoever with launch, or is the firing room different?

BARTOLONE: Absolutely. That continues all the way through launch countdown, and actually we're about twenty-five minutes from call to stations for a launch countdown here for the last flight, and we have project engineers on console twenty-four hours a day in the firing room now from here through launch countdown. Actually I have to do my shift out there tomorrow starting at seven a.m. to support the firing room through first shift. Then someone will come relieve me, take second shift, and there will be someone coming overnight and all the way until we get the STS-135 off the ground.

ROSS-NAZZAL: That's amazing. Would you tell us about some of the more memorable missions that you've worked in this position? Any stand out?

BARTOLONE: I can tell you about one of my first major integration challenges and one of the things that I think really helped me gain a lot of the respect of my system engineers was on STS-115, which was actually *Atlantis'* first flight since Return to Flight since after the *Columbia* accident. We had done something called an integrated vibration test, where we instrumented the entire stack with, gosh, over three hundred different accelerometers and strain gauges and various sensors to actually capture the load and the vibrations that the integrated stack sees while it rolls from the VAB out to the launch pad.

A lot of that was to gain some knowledge because during the Return to Flight downtime period while we were doing the accident investigation between the *Columbia* accident, there were a lot of concerns raised about the structural life of the Orbiter, whether it really was certified for a hundred flights as it was originally designed, or could the vibration that the crawler induces during the rollout have shortened the structural life of the Orbiters.

As the ET and SRB project engineer at the time and majority of the instrumentation being installed on the ET and the SRBs, because, like I mentioned, the solid rocket boosters support the entire weight of the vehicle once it's a fully mated stack, a lot of the instrumentation was installed on the solid rocket boosters for this particular test. So that was, to me, an extremely memorable experience, being kind of in charge, I guess, of this large team of people [for the first time]. Got to be a couple hundred different people involved in pulling that test off, and I actually got to be part of the small group of folks that was allowed to be on mobile launch platform while the vehicle was rolling from the Vehicle Assembly Building out to the launch pad. To see it and to be there with it as it made its slow, slow creep out there to the launch pad was just an amazing sight. To watch sunrise from the mobile launch platform as the vehicle was making its way out to the launch pad was an incredible thing.

ROSS-NAZZAL: That's a nice picture.

As you pointed out, this is the last mission that's going to fly here on Friday. What impact has this decision to end the program had on your workforce over the past six years?

BARTOLONE: Well, you know, up until, I would say, in the last six months or so when some of the larger layoffs started happening here, I think that there was, especially in the contractor workforce, there was this kind of hope that was being held out that something was going to happen, something would change, someone would come to the realization that we were throwing away a capability that wasn't ready to be thrown away. In the last six or so months I've seen a dramatic decrease in morale in the contractor workforce. It subsequently had a really significant impact on the NASA workforce here at Kennedy Space Center in seeing how much more the stress has kind of been raised on the various people that were left after the different layoffs would happen and seeing how they were coping and making sure from a personal standpoint they were keeping their focus and keeping their head engaged. Making sure that they were making the smart decision, the right decision, not because they were becoming disillusioned with their situation, but because they still had a job to do and a professional attitude to be maintained, and that was expected of them.

Just that overall morale has been one of our biggest challenges. Trying to help folks see that they're part of something special, that the work that they're continuing to do for us does matter, that there's lives that are depending on them, the lives of not only the crew that sits onboard the vehicle, but the family of that crew.

I've seen our management here go well above and out of their way, and I've actually helped and been very proud to have brought in several astronauts to come and surprise people and to be part of some of the more integrated processing activities, just to make their presence known and to shake their hands and to help some of these people realize that what they're part of is really not only unique and special, but it's historic.

It's been a constant struggle to keep my own morale up because as the months have gone by, especially this year, and you've said goodbye to close friends and people that you've come to respect, with just a tremendous amount of history and knowledge that have been, unfortunately, let go because we are at the closeout of the program. It's been a really, really interesting couple of months.

ROSS-NAZZAL: Yes, I can imagine that morale is low. It's low here at JSC too.

BARTOLONE: So much of our identity here is, like I said earlier, tied up with that launch. We get that adrenaline rush from that launch, and that's what propels us into getting the next vehicle ready to go. I think a lot of folks here not only know that the large layoff is only a couple weeks after the Orbiter lands. We're within that month from now where these people are going to be let go. So like I said earlier, that flame is getting diminished, and it will be put out here very quick.

ROSS-NAZZAL: We have just a few minutes left, and I thought I would ask you is there something that perhaps I overlooked or you think that we should discuss in the few minutes that we have left?

BARTOLONE: Well, yes, there's actually one thing that was one of the more unique opportunities or projects that I got involved with here. It was actually right around the time where I became project engineer. When we had the Hurricane Katrina that devastated New Orleans and really affected the Michoud Assembly Facility, there was a concept that was studied about possibly moving that capability to manufacture external tanks here to the Kennedy Space Center because there was quite a bit of question about whether or not the facility was going to be able to be brought back online in order to allow us to finish the Shuttle Program, because even at that time, remember, we had been directed by President [George W.] Bush that the Shuttle Program would end in 2010, that the Constellation Program would come into existence, and we would be building rockets to go back to the Moon.

So there was a certain amount of, I guess, time pressure put on us to try and meet that deadline, to finish out the building of the International Space Station by 2010. Obviously that didn't happen. Here we are in 2011. The idea of moving such a large manufacturing operation that had been located in New Orleans here to the Kennedy Space Center to allow us to build external tanks here and move that workforce who was essentially—almost 70 percent of it was homeless in New Orleans, some of which had been living in faraway states. I remember actually hearing that one of the people that was part of the assembly line there at Michoud actually relocated to Montana. They only actually got back about 60 percent of their workforce after Hurricane Katrina when they finally got the facility, the factory, fully back up and operational and be able to produce external tanks again.

One of the main things I was charged with going and doing by the Shuttle Program was trying to find an ideal facility among the different facilities that we have here that were abandoned or unutilized at the Kennedy Space Center or even at the Cape Canaveral Air Force Station that could support the manufacturing operations of external tank. We actually did identify two facilities that would have been more than capable of allowing that operation and the various equipment to be brought in from New Orleans to allow that to happen, but subsequently the [MAF] facility was able to be recovered and actually brought back online much sooner than anybody had anticipated, through an awful lot of work and money infusion from Lockheed

Martin and also, I believe, from the program management folks and people up in Washington, DC that were able to actually get Michoud back fully functional again, and they were able to produce external tanks only about twelve months after the hurricane had hit. A year later, we had production back to its full capability, which is astonishing, considering that some areas of New Orleans have yet to even recover, and it's [been] six years now.

So it was a really unique undertaking to be part of that and to lead that group of people here at Kennedy Space Center that were looking to bring that manufacturing potential here. I think it would have been a very exciting thing to have actual manufacturing of the external tank here at Kennedy Space Center, but ultimately I understand politically why it was better to leave that in New Orleans. [MAF] is one of the major industrial facilities there in East New Orleans, and it was very symbolic politically to see that facility back up and running. It was one of the more unique tasks that I got asked to go off and do.

ROSS-NAZZAL: Yes, that's interesting. Had you worked with the external tank before that assignment?

BARTOLONE: Yes, I had, just in a very limited capacity, because that was only about—let's see. Katrina was the end of August 2005. I had only been on this job for about four and a half, five months.

ROSS-NAZZAL: That's right. I'm thinking Katrina was further back.

BARTOLONE: Yes, Katrina was 2005.

ROSS-NAZZAL: That's right. In my head I was thinking it was further back in my timeframe.

Well, that's very interesting. I'm glad you shared that information with us. Anything else that you want to add? Anything about your accomplishments in this position or any other milestones?

BARTOLONE: No. I can tell you that I feel like I've been very fortunate to have had the opportunities and been involved in the various different major issues that have come up with the external tank and the handful that have happened with solid rocket booster. I feel extremely proud to be part of these teams and to have been here and to be here at such an historic time to see us go from that rising up out of the ashes after *Columbia* now to flying the Shuttle into the history books here this week. Even knowing everything that I know now and all the turmoil and unfortunate situations, I see a lot of people, my contractors especially, and I wouldn't have changed anything. I still would have taken this job, and I'm very grateful for the opportunities I've been given. This has been one heck of a ride.

ROSS-NAZZAL: I do wish you well this week, and I hope that we get off successfully on Friday.

BARTOLONE: Yes, me too.

ROSS-NAZZAL: So thank you very much for your time today. I certainly appreciate it, and I hope you have a good time at the Keys.

BARTOLONE: Thank you.

ROSS-NAZZAL: And have a relaxing vacation after what I'm sure has been a very hectic past five, six years.

BARTOLONE: Yes, it has been. It has been, and I'm definitely looking forward to some rest.

[End of interview]