NASA STS RECORDATION ORAL HISTORY PROJECT
EDITED ORAL HISTORY TRANSCRIPT

JAMES A. CARLETON
INTERVIEWED BY JENNIFER ROSS-NAZZAL
KENNEDY SPACE CENTER, FLORIDA – 13 JULY 2011

ROSS-NAZZAL: Today is July 13th, 2011. This interview is being conducted with Jim Carleton at Kennedy Space Center, Florida, as part of the NASA STS Recordation Oral History Project. The interviewer is Jennifer Ross-Nazzal. Thanks again for taking time out of your schedule to sit with me this afternoon and talk about SRBs [Solid Rocket Boosters].

CARLETON: It's my pleasure, totally.

ROSS-NAZZAL: I thought we'd start off with a relatively easy question. Why don't you give me an overview of your career at NASA.

CARLETON: I started working for USBI [United Space Boosters, Inc.] in 1978. Previously I was employed at Lockheed Missiles. I worked on the Trident Missile Program, the Fleet Ballistic Missile. When that program ended, I came over to USBI. So in 1978 they were looking for mechanical engineers and pyro and ordnance engineers. I got hired as a mechanical engineer.

So I've been working since then on Space Shuttle, totally Space Shuttle, STS-1 through STS-135. I've been lucky enough to work every mission. It's been quite a thrill really. [Today I am the director of program management for United Space Alliance.]

ROSS-NAZZAL: 135 missions, that's amazing. Since you started in '78, would you tell me what was going on [at that time]? They were supposed to launch the Shuttle at that point.

CARLETON: Actually in 1978, when I first started working here, there was no flight hardware here. There was no paperwork on how to put it together. I was hired to be one of the technical people, an engineer, to write assembly documentation for the SRB, specifically the forward assembly of the SRB. I was a forward skirt engineer. I wrote the ordnance and the mechanical installation and the mass properties paperwork for the forward skirt.

At that time the VAB [Vehicle Assembly Building] was still set up for the Apollo Program, because when Apollo ended, they just walked away from it. So we had to retrofit and activate the low bay of the VAB. We took out some stands, we put new stands in, platforms and ladders that would access SRB hardware. So my first real job responsibility was the activation manager for the VAB. That was before we ever had any flight hardware. Ultimately we got the facility ready to accept flight hardware and then in '79 we started to get flight hardware, and we started building the first Space Shuttle.

ROSS-NAZZAL: That must have been really exciting.

CARLETON: It was.

ROSS-NAZZAL: Can you tell me about getting ready for that first flight?

CARLETON: The first days were pretty hectic actually. There was no written documentation, no paperwork, no procedures, no guidelines. We had to do everything from scratch. It was a long time; working 60 hours a week was not uncommon at all. We worked quite a bit. We even worked through Thanksgiving and Christmas holidays in 1980 to get STS-1 ready. STS-1, of course, launched April 12th, 1981. So leading up to that was pretty feverish.

With the advent of no procedures, no guidelines, not only did we have to write the instructions but we had to develop our own procedures, our safety procedures, our hazardous material handling activities. Anything that you can think of that's required that's commonplace today wasn't there. We had to do it all.

ROSS-NAZZAL: How'd you come up with those type of procedures? Did you ask people from the Apollo Program? Or did you do it as you were working with the first SRB?

CARLETON: There were quite a few Apollo type folks that were still here. The word of the day was, "Well back in Apollo we did it this way" so there was quite a bit of that. We just literally took the drawings and developed the procedures from the drawings.

The Apollo is one type of vehicle. The Space Shuttle was completely unique in the fact that it's a reusable vehicle. We had to plan ahead to be able to reuse it again, where Apollo hardware is completely expendable. An interesting task, because no one had ever done it before.

ROSS-NAZZAL: Were you working in tandem with the Marshall Space Flight Center [Huntsville, Alabama] and Morton Thiokol and other [contractors]?

CARLETON: Marshall Space Flight Center was the design agency for SRB. Thiokol was the company that did the motor segments of the SRB, the RSRB [Reusable Solid Rocket Booster]. So they did their work out in Utah. They filled the motor segments with propellant and shipped them here. Our job at the time here was to do the subassembly work, the assembly and integration work, as well as the stacking. There were two contracts. There was an MBAC Contract (Marshall Booster Assembly Contract) and a KBAC Contract (Kennedy Booster Assembly Contract). United Technologies had both of those contracts in the beginning. Ultimately the KBAC Contract went a separate path, and we retained the MBAC Contract. The work that was done then by that contract is what USA [United Space Alliance] SRB still does today. This particular facility we're in, [the Solid Rocket Booster Assembly and Refurbishment Facility], is designed for the SRB work. Once we moved out of the VAB and came here and up until today it's all been just SRB and a Marshall Contract.

ROSS-NAZZAL: When did you move officially out of the VAB into this facility?

CARLETON: Think this [facility] was dedicated in 1985.

ROSS-NAZZAL: So just before [the Space Shuttle] *Challenger* [accident, STS-51L]

CARLETON: Just before *Challenger*, yes.

ROSS-NAZZAL: Tell me about that first flight of STS-1. What are your recollections, besides the ramp-up for the mission? Did you get to see the launch?

CARLETON: Absolutely. Like I said we worked pretty long hours getting ready. When we finished our first hardware, our STS-1 hardware, we transferred it across what we called the low bay at the time. Handed it off to the other contract, the KBAC Contract. We started building STS-2. We were building STS-2 and STS-3 as the other folks were prepping for the actual launch. We were here the day of the launch. We were in a support mode watching our systems, making sure everything that we had put together worked the way it was supposed to.

It was a lot different, STS-1, than the way they launch today. Being the first launch, I don't think anybody knew what to expect. We'd seen Apollo and Atlas, some of the other rockets. It was pretty fantastic to see the Space Shuttle take off for the first time.

ROSS-NAZZAL: What did you learn from that first mission that you applied [to future flights]? You said you were working on the STS-2 and STS-3 SRBs. Were there lessons that you learned from the orbital flight tests, STS-1 through 4, that you applied to future stacking efforts and processing?

CARLETON: Our job, being subassembly and integration activity, we developed learning curves and continuous improvement activities. So every single launch we learned something new. We played on that. As a matter of fact, when you're building two SRBs, you build one ahead of the other. As you're building, say the left side, you're learning something and you can apply it to the right side. So we're even learning lessons and applying them between the launches in other words. We build two things for every launch here. So we had twice the learning curve someone else might have.

ROSS-NAZZAL: Are there differences between the right and left booster?

CARLETON: Well, they're almost mirror images of each other. The forward skirts are unique, because you have to have access to them. The way that the launch pad is laid out, we have a door in the side of the forward skirt to go in and do things. So those two structures are unique. The frustums [do not] matter if they're left or right. The aft skirts can be either left or right, but forward skirt is unique. All the other components are interchangeable.

ROSS-NAZZAL: I was reading about the SRBs and when they're retrieved—I'm not sure if this relates to the work that you do—but why are they retrieved out at Cape Canaveral [Air Force Station, Florida] instead of here at Kennedy Space Center?

CARLETON: The SRBs, after a little over two minutes, are jettisoned from the main vehicle and parachute into the ocean, 136-foot-diameter parachutes. We have two ships that go and retrieve them, one for each SRB. What they do is they come through the locks into the Banana River, up the Banana River. Hangar AF is as far as they can go. There's a bridge there that goes over to the Air Force side [from KSC].

Once you get across the bridge that's all Air Force property pretty much, but we have a relationship with the Air Force. Marshall of course manages it. We operate it. It's a handshake agreement with Cape Canaveral Air Force Station to use that facility over there.

We have a couple other facilities that we're using also. We have our NDE [Nondestructive Evaluation] Labs, our M&P [Materials and Processing] Labs. It's just

convenient to be over there on that side. They do bring the external tank up to the VAB and the turn basin going under that bridge, but it's very shallow at the north part of the Banana River. We have shallow draft tugs that bring the E tank [External Tank] up there. It's not deep enough to take the [retrieval] ships up there. So back in the beginning that's where they decided to build the refurb [refurbishment] facility.

ROSS-NAZZAL: Interesting. You had mentioned earlier that launching is much different than it was for STS-1 and that you learned so much and things have changed so much. Can you give me some examples of how things have changed over time?

CARLETON: One of the biggest changes is we realized, when we were in the low bay of the VAB, we were not going to be able to process at the rate that was proposed [and] as they planned. In conjunction with that, with all the propellant in the VAB they wanted to take as many people out of that hazardous environment as they possibly could.

So this facility was designed in the early '80s and built. Then we moved in in 1985. So that's the largest improvement through the years. This facility was specifically designed for SRBs. It was designed to be able to build at a rate of 24 flights a year, because back then people were thinking that this was going to be like an airline and we were going to fly off Pad A, Pad B, maybe even another pad. I've seen maps where there's other pads past A and B, as well as flying at Vandenberg [Air Force Base, California]. The end of '85 we'd actually built and transferred to Vandenberg a set of SRB hardware to be launched at VLS [Vandenberg Launch Site]-1 at Vandenberg. So we were going to support three launch pads, and that's why this facility was built.

A lot of the work in the VAB was manual. This facility has robotics incorporated into it. We had, at the time, Niko robots, which were the largest gantry type robot in the world, to process our hardware. So with that, the manual labor of these technicians became more technical robotic operators instead of sanders. They still do a lot of the manual labor but [the] big improvement was the robotics. As we've gone through the years we've found different ways to improve on processing the hardware. Building this facility and then the robotics were two of the major ones.

ROSS-NAZZAL: Did the robotics come online also when this facility opened? Or was that something that came later?

CARLETON: We did have an articulating arm robot in the VAB but it wasn't like what we had here. These were the state-of-the-art type robots at the time. The facility was specifically designed to flow the hardware in a very efficient manner, where in the VAB we were just using cells that were available from Apollo. So we started from scratch where the hardware comes in the door here, goes to a different workstation, out the other side a completed assembly. So with that and the machine shop we built, it's just exponentially more efficient in this building.

ROSS-NAZZAL: How many people were working on stacking and assembling an SRB in the beginning compared to today?

CARLETON: I'll say from when we started populating this building. SRB was a little over 800 people at its height in Florida. So it took 800 people to process at a rate of ten or 11 a year.

After *Challenger* we actually increased the number of employees we had because we went through a design certification review. So the total company had around 1,800 to 1,900 between here and Huntsville. Here it takes 800 people 18 months to start from hitting the water to another launch.

ROSS-NAZZAL: That's a very lengthy process.

CARLETON: Consider you drop it in the ocean, you tow it back, you strip it, take every component out of it, inspect it, repaint it, repair it, send it over here, send it to this building, start the subassembly work, the TPS [Thermal Protection System] application, inspections along the way. The cables, the ordnance, the integration, the parachutes, and then we transfer it to the VAB six months ahead of schedule. It takes them six months to do their processing, stacking, and then rolling out to the pad. So it's about an 18-month cycle for us.

ROSS-NAZZAL: Can you expand on those processes a little more? Walk me through—the SRB lands in the Atlantic. You go out and fish it out. Walk us through that.

CARLETON: When the SRBs are towed in up the Banana River we have a hoist that takes the total SRB out of the water. It's called a straddle lift. It hoists it out of the water. It's a big tractor. It drives it and sets it on some dollies that are on railroad tracks at Hangar AF. There's two sets of tracks and two sets of dollies. Both SRBs come out side by side. They start the inspection and the postflight inspection process.

They see how the things performed and what kind of damage there may be on the vehicles. After that initial inspection, they go into a safing mode where they disconnect and remove the unexpended ordnance. They take the hydrazine, the fuels out. They start doing the disassembly activity. Each structure is completely stripped, totally down to the bare metal. Every component is removed. Every little piece is run into a facility called the Small Parts Facility. Those parts, if it's economically feasible, are stripped of paint, inspected, painted. Those that are so small that it wouldn't be economical to do that we discard and buy those little pieces new.

After parts are inspected, painted, subassemblies are somewhat reassembled. They're sent over here to the warehouse. Put in stores as flight-certified hardware. The structures are stripped with a robot hydrolaser. It takes the old TPS material off. It takes the paint off. Structures are re-Alodined, which is a chromatic conversion coating. They're primed, topcoated. They look like brand-new structures. They're brought over here, and we do what's called critical dimension checks.

We have big gauges out on the high bay floor where these structures are set down. We measure their concentricity, that they're still round, that they're not beat up or damaged. They still meet the dimensions required for stacking. After that those structures are taken and put in the TPS area where we reapply the thermal protection system. After the thermal protection system is applied, the TPS is cured, they're brought out. They put another coat of paint called topcoat over that to protect the TPS from moisture. After the structures are totally painted, insulated and topcoated, then they go in the subassembly area, where we install the cables and the pyro and the ordnance and the parachutes. They're integrated together. Forward assembly, for instance, is set up in the forward ACO station, automatic checkout. We do a flight sim

[simulation]. We hook cables up and simulate what it goes through during flight and do a total checkout, ATP (Acceptance Test Procedure). After the forward assembly is done, it's put on a trailer and then taken to the VAB.

The aft skirt houses all the thrust vector control hardware so we rebuild that plumbing every time. It houses the actuators that move the nozzle, the hydraulic unit which is made up of a hydraulic pump and an auxiliary power unit [APU]. The APU is fueled by hydrazine. So we put the fuel tank and all the fuel plumbing, the hydraulic [plumbing], all brand-new every time. That structure is taken out back to what we call an Aft Skirt Test Facility. That goes through a flight profile. We actually fire up the APUs. We fuel them and hot-fire them and simulate that part of the flight.

Then when that's done we do our final closeouts and paint touch-ups and then that structure goes to the VAB. Goes to the RPSF [Rotation Processing and Surge Facility] actually. The first motor segment is set down on it. All that work takes about 18 months from fishing it out of the water till they launch another one.

ROSS-NAZZAL: How closely do you follow the SRBs once they've been mated with the external tank and the Orbiter and they're out on the pad?

CARLETON: Because USA SRB has the design responsibility, we assumed the design at STS-6 from Marshall, we watch every time it's powered up. We watch it all during the entire processing. We have monitors, pressurized systems on the subassemblies. We watch them every single day. When they're finally stacked and they go through checkouts, whenever it's

powered up we have people in our facility here that watch all the signs, all the voltages, and all the amperages of everything that's powered up. We're watching it right through SRB separation.

Anything that goes wrong or anything that comes up, we have a design group here that's responsible. Does the analysis, makes a recommendation. Sometimes our technicians will go down and take care of it. Sometimes it'll be the ground ops or L&RS [Launch and Recovery Systems] folks that'll take care of the problem. It's a 24/7 job.

ROSS-NAZZAL: Have you had to handle any anomalies since you've worked in this position?

CARLETON: Seems like every launch you have an anomaly. There's always something to work. There's always some little thing that goes wrong. We don't want to be holding up a launch. So whenever an anomaly comes up, we totally put all our design capability against it till it's resolved one way or the other. If it's not resolved obviously we don't move forward. It's one of the lessons of *Challenger*. Everybody gets a vote. We have any dissenting opinions, those opinions are evaluated. We make that person happy one way or the other before we move on. But yes, plenty of anomalies.

All these LRU [Line Replaceable Unit] components, when they're removed at Hangar AF, go back to their vendors for vendor refurb, like the APU and the actuators, those main LRUs. We don't do that here. So while they're doing their refurb if they run into an anomaly or find something happened that could be related to launch, we jump right on that and resolve that problem also. So we're always working something. There's always irons in the fire.

ROSS-NAZZAL: Have there been any significant anomalies since [the Space Shuttle] *Columbia* [accident, STS-107] that you can recall?

CARLETON: Actually since *Columbia* it's become even more rigid, our procedures. We had a method of doing work, and then we had *Challenger*, and we had the [Rogers] Commission. Then we had *Columbia* and we had the CAIB report. We've tightened down and made things better.

We're launching in a very small window to go to the Space Station now. We've been nailing it for the last two years. So the big anomalies for SRB have not really happened in the last couple years. There's been anomalies on the pad, the GUCP [Ground Umbilical Carrier Plate] and some other problems. When that happens we're an integral part of L&RS now. So we get on that activity and help them. But SRB has been pretty good for the last couple years.

ROSS-NAZZAL: I hear it's been mainly the external tank that's been the challenge. You talked about some of the different inspections that you might do on the SRB. If one of them comes back damaged do you end up getting rid of that piece of hardware? What do you do with that?

CARLETON: That's just a function of how much damage happens to it. We have had to get rid of a few structures, about three forward skirts. We have received damage on the aft skirts, because they hit the water first. We've torn some rings up inside but we have a machine shop here that can repair just about everything, unless it's so damaged that the welds are fractured.

So depending on how much the damage is we might take that structure offline and do offline repairs on it. It's really very seldom do we get damage that we can't fix. They're pretty

robust structures. They're built pretty tough. They're built to hit the water over 60 miles an hour. We have had a couple, but most of the problems we can fix in this facility. We have a first-class machine shop that can make almost any kind of part. We have a 3-D printer. I don't know if you know what that is. If you scan this [shows a Coke bottle], it'll print this in three dimensions. In other words it'll build a model. We'll take that with our CNC [Computer Numerical Control] machines and transfer the information, the data points, and the design information, to the machine downstairs. It'll cut it out of metal. So we can make just about anything.

ROSS-NAZZAL: Tell me about some of the facilities. You've talked about a couple of them. Tell me about some of the different facilities here at KSC that handle SRB and different products of the SRB and its components.

CARLETON: We talked a little bit about Hangar AF, that's where the refurb activity is done. We have another facility called Hangar N where we do NDE. The NDE Facility is nondestructive evaluation, where we can do dye pen, X-ray, all kinds of nondestructive techniques. Over there is another robot that we can put the whole aft skirt inside this cell, a 14-, 15-foot diameter. The arm can come down and X-ray the structure and the welds and make sure that nothing was damaged. So that facility, that whole cell is dedicated to just the inspection and test or nondestructive evaluation of the structure.

Another facility we have is the M&P Lab. We have a whole staff of folks, probably 35 or 40 that just do materials and processing, where they make sure our paints and our glues and adhesives are what they need to be and they're to specification. They have electron scanning

microscopes, and they can do metallurgical analysis. Any kind of process control where you mix part A and part B together at a certain ratio, they can do all that.

One of our other facilities is the parachute refurb facility. That's on this side. It's on the Kennedy side. It's in back of the O&C [Operations and Checkout]. They bring the parachutes there on big eight- or ten-foot-diameter reels. They unreel them; they wash them. There's a big washing machine there. They dry them. Then they stretch them out. They look for damage. They check every ribbon, every gore, every hole, and resew them. We have a whole fleet of sewing machines over there, ladies and gentlemen that know how to do that particular type of work. They resew them and repair them and build them.

We have an Ordnance Storage Facility over here where all the pyro is stored. That's operated jointly between us and up the road at the VAB where we store booster separation motors, linear shaped charges, separation hardware, confined detonating fuses, the manifolds.

This facility, this building you're in, is the Engineering Administrating Building. In back of us is the manufacturing building where we have our high bay. In back of that is the Logistics Storage Facility where we keep everything. Over here is a GSE [Ground Support Equipment] Facility where we repair and maintain all our ground support equipment. A lot of buildings, a lot of stuff going on.

In conjunction with that we maintain two ships and the barge. The ships were originally built specifically for towing SRBs back. They were built up off Jacksonville, Florida; they were brought down here. We used them on STS-1. They were UTC *Liberty* and UTC *Freedom*, United Technologies, and then they were transitioned to NASA. They have NASA logos on them now, but they were originally United Technologies ships. We have facilities over there that maintain the ships.

If you go over to Hangar AF there's probably ten little buildings around there, besides the main hangar. We've got a lot of buildings to maintain. We have the facilities people that actually do that. They're our technicians that perform things like fixing the air conditioner here or changing lights. We do that ourselves.

ROSS-NAZZAL: How do you maintain communication with all of these different buildings and all of these people working on different aspects for the booster? How do you know there's a problem with the paint? The paint mixture has changed, or the glue has changed?

CARLETON: I have a whole group that's called Planning and Scheduling. That group integrates all these activities, puts out schedules every week. Now they're put out on the computer so everybody can see the schedule and see exactly where you're supposed to be no matter what building you're in. Of course we telecon [teleconference] every day. We have regular meetings three times a week at 8:30 where we do a status of everybody that's hooked into SRB at that meeting. If they have a problem then everybody knows about it. Put the resources against it. It's computers and phones and stuff like that. We maintain our communication.

This building is, like I said, the Engineering and Administration. So this floor, these are the directors and executives for SRB. They represent operations, safety, engineering, program. So we're all here. Everybody works for somebody. My boss calls us all in here and gives us our marching orders in the morning. [We go out and] get business done.

ROSS-NAZZAL: Have things changed in terms of communication since you started out here in '78?

CARLETON: We used to have what they called a war board. It was a big room with a piece of metal on [one wall] that was painted white. Planners and schedulers would cut magnetic strips out and print Forward Assembly 10 and stick it on the magnetic board with a certain bar. [It] had to have lines down for the months and the days. You put it up there. Then the other forward [assemblies and aft skirts]. Somebody would come in and take a picture. Once a week we'd get a copy of these pictures, eight-by-ten color glossies, and that would be our schedule.

ROSS-NAZZAL: Things have definitely changed. Now you've got BlackBerries.

CARLETON: We called those guys X-Acto commandos because they would cut these strips out. Put it on the board and make these schedules. Now we have programs to do that [and Blackberries].

ROSS-NAZZAL: That's funny. How many SRBs can you process or could you process at one time here at KSC?

CARLETON: This facility was actually designed to support 24 flights a year. We were actually at a rate of 15 a year. We were building at 15 when *Challenger* happened. Well I say build at 15, we had a rate of 15 flight sets in work. That's Hangar AF, parachute, NDE, here, and even up the road. Stacking and on the pad. So at that rate we could have flown 15 or 16. We actually flew nine missions in 1985 before *Challenger*.

That was a pretty fierce pace. In January of 1986 we actually flew two missions in January and the second one was *Challenger*. So we were at a fast pace in 1986, too. In 1986 we were supposed to launch our first Vandenberg launch. So we had Pad A, Pad B, DoD [Department of Defense] missions, regular missions, and Vandenberg missions all on the [schedule] at the same time. This facility, actually we designed it for 24, but we had contingency plans where it could have been expanded to fly 40 missions. They said, "What if we want to fly 40?" So we [generated scenarios to support 40].

ROSS-NAZZAL: You had mentioned *Challenger* several times. Did you ever feel pressure in this position to ramp things up? Get things done? You mentioned, "What if we want to go to 40?"

CARLETON: '85 was very busy, busy year. We were definitely more schedule-oriented back then than we ever have been. Thanksgiving and Christmas holiday, those times were pretty busy. We were doing a lot of traveling. We were going back and forth to Vandenberg, because we were trying to get that facility ready while maintaining this.

Like I said, we'd already built up enough, and we'd already flown nine times in '85, which was the highest rate we ever achieved. There were two other years where we flew eight missions and then the rest are five and six or four or whatever. Yes, it was pretty hectic back then.

ROSS-NAZZAL: Did you personally ever question the idea that you would be able to fly those 40 missions a year or even 24 a year?

CARLETON: I was one of the people that helped design this facility, with the idea of being able to process many flight sets. We had redundancies here. We had multiple cells and multiple test [capabilities], like out back we had two hot-fire bays. We could do a flight set. That only took two weeks. We could put another flight set in.

So we had designed this place right to be able to meet that demand. We could stay ahead of E tank or Morton Thiokol or the Orbiter people, because we got the opportunity to design and build this [facility] just for that. Everybody else—well, I guess the OPFs were designed of course to process Orbiters. But most of the other folks had to use facilities that were here [since Apollo]. Didn't have the advantage that we had.

ROSS-NAZZAL: Would you tell me a little bit about building the facility? When did you start putting pencil to paper and say this is what we want? This is what we're going to need.

CARLETON: About I guess '82 or '83. '83 we started. We were actually looking for a site off Kennedy Space Center, originally. Thought it would be better if we were off the Space Center. But ultimately this location was decided upon. We used to have a fence out front, inside was Marshall Space Flight Center, outside was Kennedy. Yes, we had a fence and gates and stuff like that at one time. You couldn't come in like you could today. You had to have an escort even to get to here.

ROSS-NAZZAL: Interesting. It says a lot about inter-Center rivalry.

CARLETON: I don't think that has gone away yet, at least not during my shift of 35 years.

ROSS-NAZZAL: Interesting. Well, tell me about *Challenger*. Were you working that flight?

CARLETON: Yes. I was working *Challenger*. My crew had built the forward assemblies for Challenger. We had already run into a minor problem on STS-4, where we had a parachute failure and we lost two SRBs. After Challenger happened, we were very personally involved with it thinking that it might have been something that we had done wrong. I was standing out in the LCC [Launch Control Center] parking lot when that happened.

I could tell immediately what happened. A lot of people were in awe and didn't understand or couldn't comprehend it. But when I saw the SRBs leave I knew exactly what happened. Subsequently to that I was asked to be the technical correspondent on the Johnson Sea Link submarine. I went out for six weeks and identified hardware in a submarine. Picked up pieces till we ultimately found the piece that was what they called the smoking gun. That was retrieved to verify. *Challenger* was a tough time. Of course the family was here and everything. It was pretty tough.

ROSS-NAZZAL: I see from your resume that you did some work with the Rogers Commission. You received a certificate.

CARLETON: That was partly for the work I did. A lot of folks, I'd say anybody that could do anything to help was doing that so that certificate is not really that big a deal, because everybody was trying to help. Probably my work on the submarine is what that was all about. I was in the

service. I'm retired from the Marine Corps, but I was always on the ground, and I'm not a pilot. So going on a submarine was a pretty rare experience.

ROSS-NAZZAL: There were definitely some changes made to the solid rocket motor. Tell us about the changes that were made to the SRB and how that impacted ground processing here.

CARLETON: The SRB, after *Challenger*, we did a complete design certification review. In other words the entire design was reviewed by our engineers in Huntsville. So during that process they found several things that would require or needed improvement. We actually had about six flight sets of hardware in this facility ready to go so we tore all that hardware down right to the very beginning, incorporated the design changes that the CDR [Critical Design Review] results provided, and rebuilt all the hardware back up again. There was many many design improvements during that period. So I can't really single out too many. A lot of different things were done.

ROSS-NAZZAL: Were there changes made to this facility as a result of the changes made to the SRB?

CARLETON: Not really, because the rate was a lot slower. We knew that we were never going to fly nine again, or we didn't think we would. Of course we did get up to eight. There were some things that were done, but the facility here didn't change much. It was more some of the hardware that we improved on.

After *Columbia*, the CAIB report came out. There were improvements that we made as a result of that. The bolt catcher is one. There was a question about the bolt catcher. The bolt catcher was a welded design. The testing as a result of the CAIB report indicated there might be a problem with the welds. It might be a possible failure mode. So we took that, redesigned the entire bolt catcher. We machined a solid piece of aluminum billet. So it's all one piece.

Then the insulation that protects it used to be SLA [Spray-On Lightweight Ablator], and we machined cork and put over it. So our machine shop can cut metal or cork. We took solid cork blocks and cut out the silhouette of the bolt catcher and put that on, which improved the TPS material tremendously. As well as now you have a solid piece of something, instead of something welded together. That was probably one of the biggest improvements that SRB did after *Columbia*, the bolt catcher.

ROSS-NAZZAL: What are your recollections of both of those returns to flight?

CARLETON: *Challenger* was over two years. Well, so was *Columbia* I guess. At least the first time, the big thing was getting past the two-minute mark and letting the SRBs separate safely away from the vehicle. That's what the problem was with *Challenger*. So we were waiting for that. Everybody was holding their breath for two minutes until that happened.

As far as *Columbia* goes, we knew something was going on there because we had TPS shedding in the past, but I guess we just didn't have the wherewithal to stop and figure it out. So afterwards we're very very conscious of even the smallest piece of debris. A quarter of an inch at the right velocity can go through a wing panel. We really intensified our activity as far as debris and debris studies and releasing any kind of debris that might possibly impact the Orbiter.

In the past we didn't think foam would break through a wing, but at the right velocity and speed it can. So we concentrated on our thermal protection systems and made sure that they stuck on the vehicle and nothing was liberated.

ROSS-NAZZAL: What is the SRB TPS made out of?

CARLETON: The majority of it today is called MCC (Marshall Convergent Coating). The stuff we use today is a combination of ground cork, ecospheres and an epoxy material. It's sprayed on but it's mixed at the nozzle. In other words you have the cork and the glass and the adhesives coming out. It mixes right at the nozzle, and then it's sprayed on the vehicle.

In the past we had a different material, called MSA (Marshall Sprayable Ablative), that was a slurry. It was 40 gallons of MEK (methyl ethyl ketone) and 40 gallons of PERC [perchloroethylene] put in this big vat with our ecospheres and our other TPS materials. That was mixed up and then that was sprayed on the vehicle. So if something happened we had 80 gallons of this hazardous environmentally unfriendly material to deal with. As well as when it's sprayed on the vehicle these chemicals had to gas off so we were polluting the environment with these fumes. Through the years they developed this convergent spray technology where you don't have the big vats of material. You mix it right at the nozzle and spray it on and got rid of all the MEK and PERC. It's pretty robust material. Actually when it dries it's just as good, or adheres to the structure better than the older materials. Of course it's done robotically. That's the majority of the acreage. We also put cork pieces on certain areas where there are fasteners or protuberances [and] where the spray doesn't work right. So between those two materials that's 95%. It works pretty good.

ROSS-NAZZAL: When did you make that change?

CARLETON: From MSA to MCC? I don't remember that. '88 maybe, something like that, '89. It was a significant improvement because any time you didn't have the mixture exactly perfect you had to dump that out and start over, and that's 80 gallons of this hazardous material. Our environmental folks, they love me when I don't do things like that.

ROSS-NAZZAL: You did bring up the use of hazardous materials and talked about how some of the processes are done robotically now. How do you protect some of the people in the field who deal with some of these hazardous substances?

CARLETON: [For] each chemical that is used we have evaluated totally for protection of the individual. If it even offgasses the least bit of a fume they wear respirators, goggles, face shields, protective clothing. So it's totally evaluated where we are protecting the people from any of these hazardous materials.

There are not just the personal protective equipment but we have controlled areas where you can't go into if this operation is going on. There's elaborate sensors in most of these facilities to either determine if there's a lack of oxygen or increase of nitrogen, or there's a fuel present, or if a fuel is leaking. So this facility is evaluated on a daily basis for those kinds of things, and all the processes go through not only the engineer and the quality person, but a safety review of every single piece of paper. The safety community signs off that it's okay to do this with this particular material. It's very controlled.

ROSS-NAZZAL: You mentioned safety, and I was curious if you could talk a little bit about how the culture of safety changed after *Challenger*.

CARLETON: Well, as far as SRB goes, it wasn't so much *Challenger* as it was we had several accidents, particularly at Hangar AF. One of our directors, the head of safety, had seen or heard of this DuPont safety training. We had to do something to stop our folks from getting hurt. So we went through this cultural thing where every single employee had this DuPont safety training. Every employee had the ability to stop any process at any time. If he didn't feel like he was safe he had the ability to stop. Where in the past, before *Challenger*, the schedule constraints didn't let you. These guys, they weren't listened to very well. So we had this DuPont safety training, and it changed the whole culture of SRB. Everybody was responsible, everybody had to look out for each other, and everybody had the ability to stop any job at any time were the three main points of it.

Ultimately the rest of KSC adopted the same type of training. I think many of the contractors picked up the DuPont training. That was a result of problems that DuPont Chemical had had at some time that they did that. So [Safety] really turned around specifically [at] Hangar AF [after the DuPont safety training].

ROSS-NAZZAL: That was prior to *Challenger* then.

CARLETON: No, it was after *Challenger*. It wasn't so much *Challenger* that changed SRB as it was—we had quite a few accidents at Hangar AF. So we had to do something, and that's what the safety director came up with.

ROSS-NAZZAL: Those were accidents with divers, or?

CARLETON: No. The divers, that's one of the safer areas, even though it's a hazard op [operation]. Those guys know what's going on. No, it was people getting cut, working small parts, their hands. Slips, trips and falls, just lousy housekeeping over there. The refurb area is not like here. This is a very clean environment. Over in refurb where you're tearing apart the old rocket, it gets dirty quick. Housekeeping was not as good. There's a lot going on. That was the first place where the accidents occurred, and so that's where we had to focus on improving it.

ROSS-NAZZAL: Over the years the SRB Project had a number of improvements. There were changes. Did that impact the way you processed or impact schedules as these new changes came along?

CARLETON: We always were looking for "continuous improvement." We had a program called LIFT in the SRB world. I can't remember exactly what the acronym meant, but it was a suggestion program. So if you had an idea of a way to improve a certain process it would be evaluated by engineering or whatever [organization]. If it was really something that made an improvement, saved the company money, you got a certain percent of that savings. So everybody wanted to put LIFTs in. We got suggestions—chain the lid of the garbage can to the

garbage can so that we don't lose lids, you know, from one extreme to the other. A good 30% or 40% of these ideas were from the people, the grassroots. They knew what was going on. It was an opportunity for them to make improvements. It was a good program. We made a lot of improvements that way. The guy doing the job said hey, it's better if I go this way than that way. Why not listen to him? Through the years that program worked well.

ROSS-NAZZAL: So changes from the ground up, not only the top down.

CARLETON: Well, management, myself included, a lot of times we think we know what the heck is going on, what's better, but until you get down there and roll your sleeves up and actually do the job you really don't know what it takes to do it. The management provides the wherewithal and the finances and the time to make these improvements, but the best ideas come from the floor, from the guys.

ROSS-NAZZAL: What kind of training do the techs have who work on the floor?

CARLETON: I can tell you what I've had. I've had ordnance training, SCAPE [Self-Contained Atmosphere Protective Ensemble] training, all kinds of safety classes, torquing, forklift driving. They each have a skill card. As they take these courses it's recorded, and then they're allowed to operate this type of machinery. So depending on what their job is and what their job requirements are, they're all trained for these skills.

Once a year we have what's called block training where the basic annual requirements are met. Everybody goes to block training in the SRB. We all take the same classes, all go in

the auditorium and do it at the same time. Then those that require additional skills or additional training take the specific truck driving training, crane operating training, hazardous fuel loading training or whatever.

They all have to have their cert [certification] cards. They all have to have them up to date, and in the paperwork it says what skill certification is required. When they stamp the paper, that says that that skill is up to date, so on and so forth. We've gotten a lot more automated now so they just get a note saying hey, your training is coming due. Before it used to be a piece of paper, and we had to check the dates against their card. Now it's all in the computer. There's a lot of training that goes on.

ROSS-NAZZAL: I can imagine out here.

CARLETON: It takes a long time. If you were to hire a technician with no previous experience, it'd be eight months before he was capable of really doing any work. That's if he knew what he was doing from the outside. Just to get all the training in, because obviously you can't send a guy to training every single day eight hours a day till he gets certified, so once a week, once every third day or something, till he gets certified. It takes about eight, nine months.

ROSS-NAZZAL: How closely do you work with the vehicle managers or the other element managers while you're working on the SRB for flight?

CARLETON: I'm in a position as the program manager, so I have to work pretty close through my scheduler and planners with what's going on up the road, because they're waiting for me to meet

my schedule commitments. So I'm in communication with them minimum once a week with the activities. Like I said earlier, the engineers are watching what's going on daily on their particular system. Overall integrating with the vehicle and the rest of the folks, it's minimum once a week I go up to the OSB [Operations Support Building] and meet with all the people from all the other elements and other contractors and Marshall and Kennedy and the NASA folks.

ROSS-NAZZAL: Are you the person that signs off on the SRB that says this SRB is ready to fly?

CARLETON: Yes, one of them. I sign for program. The engineer signs, the chief engineer; the director of manufacturing signs. I used to be the director of manufacturing, and then I would go through a complete review of all the paperwork prior to. Now I expect him to do that, and I do the program type review. We sit down. We have usually it's a videocon [videoconference] with the customer. We go through all the stuff required for certification and what we call COFR, where we sign a certificate of flight readiness (COFR). We present that to the customer and tell them that we're ready to go. Then if everybody concurs, we got no dissenting opinions, we all sign that piece of paper. Then go forward to the big flight readiness review up in OSB-2.

ROSS-NAZZAL: Any big issues since you've been project manager on the SRBs?

CARLETON: There's been a couple times when I've been pretty hesitant to sign the piece of paper, and I've made some people do some other work. But pretty much by that time everything's been pretty much ironed out. We do it before we transfer the hardware. The COFR is already after the hardware transfers, as far as the customer and the rest of the community.

Because we build so far ahead, we're a year ahead of what's going on. Like I said earlier, it takes 18 months. Well, at the end of a year, there's still six months left for the activities up the road. We're pretty much done. It's fixed before we get to that [point in the launch schedule].

ROSS-NAZZAL: So you were ready to fly STS-135?

CARLETON: September, last year. Yes, and I didn't change my opinion from September till last week. We were ready to go. There were a couple issues that came up during that period from STS-134 that we had to work, but they were not big issues where I would go and say I'm taking my signature off. We can't do it. They were things that we worked out.

ROSS-NAZZAL: Can you tell me what some of those issues were?

CARLETON: We had found that in postlaunch photography—we have a lot of cameras on the launch pads, on the vehicle. We have a forward skirt aft-looking camera. We have an ETA [External Tank Assembly] ring forward-looking camera. We have a camera that looks up through the top and watches the parachutes. We have a camera that looks out the side and watches the external tank. It was to view the insulation on the external tank. When the tank peeled off during STS-134, as it did we saw this cylindrical object fly past the camera lens. So we had to figure out, where did that object come from.

As I said earlier, we do not want to let any debris from SRBs go anyplace. So we did photographic evaluation. The guys in the photo labs tried to determine how big this thing was and where it came from: if it was from the external tank, if it was from the joint between the E

tank and the SRB, or if it was something from the SRB. Well, in our evaluation we found post flight on STS-134 that there was this little piece of a grounding cable that was in the range safety system crossover that possibly could be liberated.

So we did a lot of testing to figure out if that was the piece we saw. In my mind, it was never the piece. It didn't come from there. So I was happy with what they were doing, even though they were pounding it flat and beating it to the ground. Before they ever got to the end of their evaluation, I was okay with it. I still don't think that that little piece is what we saw in the camera, and it didn't come from SRB. So I was happy with the COFR process for 135.

In that process we walked through that scenario, and said hey it could be this, but we don't think so. Let everybody else also have an opinion on it. It ended up being something we really could not pin down. I think it came from the E tank, because I'm an SRB guy. But the E tank guys think—.

ROSS-NAZZAL: I'm sure you're doing this, [pointing to one another], right?

CARLETON: It's not really that dramatic. But I'm sure it didn't come from us.

ROSS-NAZZAL: As I came in today you mentioned that you had just picked up the SRBs. Would you tell us what you're doing [now]? This is the final flight.

CARLETON: Well, we're doing the normal things. We're evaluating the hardware, make sure there's not something weird going on that we would have to report, because the Orbiter is at the Space Station now. If we found a big hunk of something missing, or some big problem, we

would say, "Hey let's evaluate this," because might have hit the Orbiter. So we still do our same evaluation, our same postflight analysis, even though it's the last flight. We want to make sure the Orbiter is okay for reentry.

We have the responsibility to safe the vehicle, take the unexpended ordnance off, take the fuels out. Do the disassembly and make everything safe for either disposal, scrapping, or the transfer of the hardware to a new program. So we're pretty much conducting our postflight evaluation, safe, and deservice the same way we always have. We won't go into the refurbishment activities where we repaint and redo all of that. Instead we'll go into what's called a preservation mode where we're saving the hardware for a future program. But we won't go into the repainting and all of that.

ROSS-NAZZAL: What will happen to all these various facilities? Will they be mothballed?

CARLETON: Some of them are being deactivated. We're hoping that the new architecture for the new space launch system will include SRBs so that these facilities will still be used, and the folks that are here will still have work. There'll be some of them that are closed and mothballed, even if there's a new program. I can't really say what the new program is going to be because no one knows. They're probably going to use SRBs at least for the first couple test flights. So that'll be good for these guys here.

ROSS-NAZZAL: Tell me about some of the safety enhancements that you helped to implement. I think you had on your resume procedures, facilities, and ship operations. If you just want to give a couple of examples.

CARLETON: Other than the normal type safety improvements that you would do as the manager or the director of manufacturing, probably the most significant thing that I actually implemented was the idea of having a pharmacy to dispense chemicals and paints. Every technician or every two or three technicians used to have what was called a POL locker, paint and oil locker. So they all had their own chemicals all over the floor. There was 20 or 30 of these lockers where the technician would go and get the glue out or the paint. Sometimes it was two components, and they'd mix it together and then put it on the rocket.

First of all it was a fire hazard. Second of all you couldn't control it. You didn't know if they were mixing it right or not. Some guys know how to mix it, some guys didn't. Even though there were procedures, there were inconsistencies. Just the housekeeping, you know, do you have it on the right shelf in your locker? Do you have acids and oils together?

I was the implementation manager of what we call the pharmacy. We now have a facility downstairs where there are specifically trained individuals that are in this facility. You bring your work order up, show them what you need. They scan your work order. They review what chemicals you're going to use for this job, and they prepare them there. They're like lab technicians. They mix them, the right quantity for a specific job. They dispense them. They weigh them, dispense them. You bring back what's left. They dispose of them in the correct environmental manner. So we took all these POL lockers off the floor.

Obviously it was a significant environmental and safety improvement here. It was very successful. We also removed Trike, trichloroethylene, as a solvent off the floor during that process, which is another one of the chemicals that the environmental folks don't want us to use.

In this facility that was probably one of the most significant safety and environmental improvements that I was involved or responsible for.

When I had the ships, I was lucky to be able to do a lot of work with the ships. We put a Welin davit systems on the ships, and that is a system that deploys a lifeboat. It deploys it automatically, if something were to happen to the ship where it would go down or was sinking, this Welin davit system would place the lifeboat in the water automatically. Prior to that we had to have crews do a crane and lift a boat out from the back of the boat. So this was an enhancement that was compatible with the SOLAS (Safety of Life at Sea). It's a shipping regulation. So this was a significant improvement with that particular part of the boat.

We were also able to implement an antiroll system in the ships. I spent quite a few missions on the ships, going back and forth. Then I was on a couple [other] ships that had this unique antiroll system in it. So we were able to convince the Marshall folks that we should do this. What it does is pump fluid back and forth inside the ship, and it stops you from going like that [demonstrates]. It's smoother.

We also implemented the use of nitrox for the divers. Nitrox allows you to dive at a deeper depth than you can on oxygen mixture. Although we don't allow the divers to go any deeper than they normally do, they have this extra layer of depth that they could go if they need to. In other words they can go deeper. That means they're [spending] less time coming up when they use this mixture of nitrogen and oxygen. The divers all wanted to do that, because most of them are pretty much sport divers so they turned me on to it. It was an easy sell for Marshall, and I was able to get that done pretty quick and increase the safety for the divers themselves. So those are some examples that I was fortunate enough to be able to work on.

ROSS-NAZZAL: You mentioned you were on some of the ships for the missions. Can you tell me about that?

CARLETON: If I could get away, I'd always take advantage of it. There's 28 people on the ship, and there's a few divers, and then there's room for a couple technical observers. In the winter months it's pretty rough at sea. Sometimes you don't get a lot of volunteers. So I would always go and fill that berth up. As soon as you get out of the port, you're with the crew. So all the things back here were—even when we had cell phones, a couple miles out, cell phones don't work. It was pretty nice to get away.

The cook on board was a fantastic cook. I always, if anything, gained weight when I was on the ships. If we went out and the launch was delayed a day, we stayed there and did some fishing and caught fresh fish and had them that night. Then I was able to see exactly what they did, what was required to actually retrieve, bring the stuff out of the water, do the chutes, do the diving, get in and out of the small boats. You can hear about it and even see videos, but unless you go do it and are there with them you really don't have a feel for what's going on. At that time I was responsible for both ships so I took advantage and went out on them every chance I could. A lot of good memories going to sea with those guys. It's fun, even if it was in the winter for the most part. I've seen a lot of people get sick on the ships though, but when we put the antiroll in, made it a lot better for them.

ROSS-NAZZAL: I can imagine. What are some of the more memorable missions that you've worked on since you've been here? Obviously STS-1 has to stand out in your memory.

CARLETON: STS-1 of course was a big one. STS-4 was my first introduction to the possibility of things going wrong. We lost both SRBs on 4. It ultimately ended up being a design error. We fixed that pretty quick. We found out what it was and fixed it. Of course *Challenger* was. The ones going up to *Challenger*, because we were at such a rate, I can't distinguish those too much except for the set we built for VLS-1. I was at that time also the program manager for the Vandenberg launch site. So we loaded the hardware on a C-5A airplane and flew it to Vandenberg and offloaded it.

I was involved in all of that. I flew out on the C-5A. We were there for all the meetings to set up that launch site, because we had already launched from Florida obviously. So they considered us folks that knew a little bit about what was going on. Getting ready for VLS-1 was significant, even though we didn't launch. That was a lot of fun flying out and back.

Challenger of course. Then return to flight, [STS]-26, that was a pretty good day. There were different missions along the way. When we put the first cameras on, the engineer that put the recorder inside the forward skirt, there was a port on the recorder for a microphone. So he went down to Ace or RadioShack and bought a microphone and stuck it on it. Nobody knew he was going to do it. It wasn't part of the design. But he said, "Hey, let's do that."

So when the tape came back, the very first time we had these videos with that particular system, we heard what it sounded like to separate from the main vehicle and fall back in space, and water impact. It was pretty fun. Sounded like whales moaning, because it's coming back into the atmosphere. You can hear pieces of what is called slag that comes out of the motor after it stops firing, bouncing off the SRB. It was pretty neat. That one was a fun mission.

These last few have been very dramatic, because you know the end is coming. We've had a lot of special activities, a lot of photo ops. The guys and gals have been able to go to the

launch pad and get their picture taken with the vehicle. They've been able to get into the vehicle. We've had tours on top of the VAB. Just to let everybody feel and touch everything they can in these last few launches. Then of course Friday [the launch of STS-135]. So a lot of good memories, a lot of good launches, a lot of fun.

ROSS-NAZZAL: I did want to ask you one other question. You said you started out working for United Technologies, USBI. Now you work for USA. That changed out in '99 I think. Any changes as a result of that switch that you noticed?

CARLETON: I worked for USBI since '78 to '99. United Technologies, a wonderful company. I liked it a lot. They asked me if I wanted to be the base manager to keep a UTC flag here. I had an offer of staying with United Technologies and starting a little office here.

USA offered me the job of director of manufacturing. Seeing as how I grew up with these guys, I was thinking probably stay with the project, the SRB Project. So when the opportunity came I took that and was able to more or less be one of the guiders or directors of what was going on, of the new SRB. Either good, bad, or indifferent, it's probably part my responsibility, the way we ended up. I can't blame any of my management, that's for sure.

ROSS-NAZZAL: Do you want to take a look at your notes and see if we may have overlooked something? Or is there something that you think we might not have covered about the SRB and processing?

CARLETON: Man, we've done a lot of talking.

ROSS-NAZZAL: Hope I haven't tired you out too much.

CARLETON: No, it's all right.

ROSS-NAZZAL: Just want to make sure we gather those details before you retire, of course.

CARLETON: I'm going to retire, but I'm sort of not going to retire, so we'll see what happens. I don't know. I guess the bottom line of it all is I've done this for [as] long as I can remember. My father took me out in October of '57 to see the Sputnik go over. Ever since then that's pretty much all I wanted to do. So it's been pretty good for me. I always say what more could you really ask for but to work on your dream. Great dream, with an even greater team, which I've had a great team. So basically that's it in a nutshell. It's been great.

ROSS-NAZZAL: Well, I thank you. Thank you very much for your time today.

CARLETON: My pleasure.

[End of interview]