NASA JOHNSON SPACE CENTER ORAL HISTORY PROJECT
EDITED ORAL HISTORY TRANSCRIPT

KEVIN C. TEMPLIN
INTERVIEWED BY JENNIFER ROSS-NAZZAL
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ROSS-NAZZAL: Today is March 27th, 2012. This interview with Kevin Templin is being conducted in Houston, Texas, for the Johnson Space Center Oral History Project. The interviewer is Jennifer Ross-Nazzal, assisted by Rebecca Wright. Thanks again for taking time out of your schedule today. We know that you're very busy with meetings and getting ready to ferry orbiters.

TEMPLIN: Thanks for inviting me.

ROSS-NAZZAL: We're looking forward to it. Tell us how you became a co-op for JSC.

TEMPLIN: I was a student at Texas A&M [University, College Station], aerospace engineering major. I heard about the co-op program in my first semester freshman year. It all sounded great until the latter part of the conversation where the co-op adviser said, "And it will add about a year, year and a half to your studies." Last thing a freshman wants to hear, so I dismissed it at that point.

It wasn't until my junior year, which is rather late for a co-op to start. I had several friends in the program that were co-opping with NASA, a couple with at that time McDonnell Douglas [Corporation] here in Houston, and they really encouraged me to get involved. So I applied, and I ended up doing three co-op tours between my junior year and graduating. Did one in Mission Operations and two in Engineering here in Houston, and really liked the work.

Always thought I'd graduate with a degree and go build aircraft. Thought no way they'd hire me to do spacecraft, there's too many smart people here at NASA in that department for them to consider me. But the co-op program was a great step forward in that, and I've encouraged others since then to get involved with that sort of thing. As a student, if any of them are like me, you seem like you're forgetting more than you're remembering. It's like, "How am I ever going to become a good engineer?" You get to work in that environment—and this applies more to engineering—it's just great to actually see how you take the academic and apply it in the work environment, and do that concurrently with your studies. It really helps.

ROSS-NAZZAL: So you came here just before *Challenger* [STS 51-L accident] in the fall of '85?

TEMPLIN: I started co-opping in May of '84 and was offered a full-time position before my last semester at A&M. I graduated in December of '85 and started full-time mid January '86, so I was on board as a full-time employee for two weeks when *Challenger* happened.

ROSS-NAZZAL: Did you have any involvement in the changes that were made to the vehicle as a result of the *Challenger* accident?

TEMPLIN: They were trying to get back into a flight mode quickly because there was a payload on that flight, a TDRS [Tracking and Data Relay] Satellite, that they lost that they wanted to deploy. So one of the first tasks that I was a team member on was to look at trying to fly a vehicle without a crew to see if we could deploy a satellite. They were looking as early as maybe the May timeframe of 1986.

Very shortly after that, they had zoned in on what the cause of the problem was, the solid rocket booster and the hot gas getting past the O-ring. They had looked at potentially putting steel bands around the joints and putting a TDRS satellite on board, so I did some work there to see what we had to do to automate a vehicle. A lot of stuff, more steps to automate flight and deploy payloads than one would think in something as technically advanced as the orbiter.

Of course we never flew that mission, but that was the first involvement. I'm on board two weeks full-time and quickly thrown into something like that. That led to my next task, which was to look at enhanced crew escape options for Space Shuttle orbiters. We wanted to get back into flight mode. We had an issue obviously on *Challenger*, and they wanted to see if there wasn't some way to provide the crew a way out if they had another disaster.

The *Challenger* event happened during ascent, and the vehicle broke apart due to aerodynamic loads after the external tank broke apart. The forward fuselage came out somewhat intact. We'll never know exactly how much, but through video we could see that it was coming out of the fireball. So the questions were could we have landed the crew cabin and the forward fuselage?

[The crew module was] much bigger than anything we've ever landed with people on board. We went to the military, and it's just bigger than anything they had any experience with, so we looked at other means of getting the crew out of the cabin. I spent a number of years working different projects with that. Most people are familiar that there was a Phase 1 project that ended up with the escape pole that we actually flew until the last days of the Shuttle program, which was a bailout system. The vehicle has to be in stable flight, you have to be able to depressurize the cabin, blow the side hatch out, then deploy the pole, and then actually get to the middeck so that they could bail out.

That was very limiting, so Phase 2 was to look at things where you may not have as much control. It was very challenging though to get seven people out of two decks on an aircraft or in this case a spacecraft. There are some aircraft that have gotten as many as four people out of two decks, so a lot of work with the military, with the Air Force and the Navy, to find out what they had built in aircraft. Presented our challenges, got input from them over the years.

We looked at different things, but you quickly run into issues. Adding these systems to the orbiter affected its aerodynamics, it affected its payload capability, and that's before you even start looking at the complexities of trying to sequence that many crew members to eject if they're in ejection seats.

A lot of work, a lot of things documented, but those all became technical challenges we chose not to pursue. The cost to modify the vehicles was so great that we determined that investing that money into some of the areas that we saw the most need to increase safety, that might cause an accident that you would actually want to get away from the vehicle through one of these systems, it was better to invest the money in those systems than it was to try and modify and put in an escape system.

It looks good on TV, and a lot of people have misconceptions about what ejection seats can do. The most capable ejection seat the United States has ever built, at least that's publicly known, was put into the SR-71 reconnaissance aircraft which flew at extremely high altitude. That is the seat that NASA actually flew on [OV (orbiter vehicle)-101] Enterprise during the Approach and Landing Tests for the pilot and commander and on [OV-102] Columbia for the first four flights.

But that seat's capability maxes out around 85,000 feet of altitude. We fly through that altitude on ascent in the Shuttle in [less than two] minutes, so would you want to invest hundreds of millions of dollars to put a system in that's only good for two minutes during ascent? It's also usable during descent, but you have to, again, get down to an altitude where it's usable.

For instance, the *Columbia* accident [STS-107] happened at such an altitude that ejection seats would not have been useful. Not everybody understands that. You can look at it and say wow, "NASA had the opportunity to put an escape system on board after *Challenger* and they didn't do it. Why didn't they do that?"

Well, your car doesn't have ejection seats. Cars are dangerous, but there's a certain amount of risk you accept. You have seatbelts; you have airbags. We have done things to mitigate risk in the Space Shuttle system and that was to make it as safe as possible in flight under certain flight rules.

ROSS-NAZZAL: So you looked at ejection seats, what else did you look at? Did you look at the Apollo program where they had the [launch escape system] to remove the crew?

TEMPLIN: That's really where we started. We did see that the crew cabin, the forward fuselage, had come out of the breakup more or less intact. We realized it had been depressurized. It had too many penetrations into the crew cabin to have maintained pressure integrity, and at that point during *Challenger* the crew was not wearing a full pressure suit.

That's one of the things that's led us to put [crew members] back into full pressure suits after *Challenger*. If you notice, they went from the blue jumpsuit back to a full orange pressure suit. That was the first step. We wanted them in a pressure suit so that if the cabin depressurized, they didn't lose oxygen and suffer from hypoxia and pass out. Small mitigating steps to try and allow the crew to try to interact with the vehicle if a smaller incident happened.

You start looking at the weight. You go back to Apollo, and you're landing a capsule that was somewhere on the order of 12,000, 13,000 pounds under three very large parachutes. The loads, when they hit the water, are substantial. They were lying on their back, because the best way to take a high-impact load is either inward through the chest or outward through the back. There was a collapsible structure in there to actually absorb some of that load.

Look at the Space Shuttle, you've got seven people sitting up in chairs. You could try to make it so that they landed on their back, but the chairs themselves and their attach points weren't designed to take the kind of loading—if you could get it to the same load that the Apollo capsule saw when it touched the water. Take that and then multiply the fact that the cabin itself weighs 30,000 pounds with all the avionics on board and everything that's inside that pressure module. If it has any forward fuselage structure around it, it gets even heavier. So now the chutes you need to try and get the touchdown velocity—to even the same point as in Apollo—have to get even bigger or more parachutes have to be included.

You're increasing the complexity of the system now, and again, the structure wasn't built for this. The cabin that the crew actually sits in is pressurized; it carries no external loading. The forward fuselage structure around it carries the loads. To subject that cabin to these touchdown loads, you would have to beef it up. So now you're adding more weight.

You can just see these things are feeding on themselves, they keep multiplying. You quickly get to the point where you go, "Well, technically I could do this but I have changed the design of the orbiter so much, I have added so much weight in the front end, that I'm limiting what I can put in the payload bay. If I want to maintain the capability I had before, I have to increase the performance of the engines." It just ripples through the entire system to where you're going, "It wasn't designed for this."

There are certain modifications I just cannot implement without losing sight of what the original mission was for the airplane, that and the cost. It's one thing to know you want that. You make that a requirement up front, and you build around it. It's completely different to have to come back and retrofit, and in this case it was prohibitive. The technical challenges, while they might have been able to have been overcome, coupled with the cost and what it was going to do to the capability of the vehicle just made it such that it was better to invest that money in other places.

ROSS-NAZZAL: Had there been planes that had been retrofitted that you looked at that increased their safety margins after an accident?

TEMPLIN: We didn't identify any. If you went back as far as World War II, you see the first implementation of the original ejection seats. The Germans had some ejection seat capability, but the design of the seat was fairly crude. Aircraft in World War II had operational ranges probably in the 20,000-to-30,000-foot range, so we quickly got away from that because that wasn't going to do us [any good].

You have to go and look at the most recent technology. That's why you go to the Air Force, you go to the Navy, and you say what are you flying in your high-performance aircraft? You look at their ejection seats, because their aircraft are now going to operate at 30,000, 50,000 feet, and much higher velocity. But still not the velocities we're going to see. We accelerate very rapidly on ascent and are outside the operational capability of the ejection seats very quickly from a speed standpoint.

Then you have the altitude issues. If you get above 10,000 feet, if you don't have supplemental oxygen the crew member would at the very least pass out from hypoxia. If it's very high altitude they could die. You start having to augment that seat, then it gets to the point where it can't work. That's why I referenced the SR-71 seat, because the crew members there, if you're flying at 85,000 feet— it's horizontal flight, not vertical; they're not going up, but very high velocity as well, high-performance aircraft. What would that seat do for us? It's the reason we selected it to begin with, but we did not include the ejection seats on *Enterprise* or *Columbia* for extremely high altitude or high velocity.

The concerns were more on approach. We had designed a whole new thermal protection system that was going to be tested for the first time really in flight. You have 30,000 tiles on the vehicle, and if you lose tiles in a critical area and you have a burn-through you may have to get out. Hopefully the vehicle gets down to an altitude where the seat is capable of being actuated in saving crew members. You have entry interface on return at 400,000 feet altitude, but the seat becomes usable at 85,000 feet, so you have a ways to go before you can say, "I hope it holds together, and then I can eject."

You see the limitations on the technology we have. SR-71 ejection seats are not really the most current. They're just an example of something that we flew and have examples of actually being used at those altitudes and velocities and being successful in saving crew members. That's why we gravitate to that sort of thing, but it really illustrates that the environment we work in when we do spaceflight is so much different than anything else that's normal for people to reference.

I mentioned cars don't have ejection seats, but a better reference than that is the airliners don't have ejection seats. You put 130 people—or if you have a large aircraft you may have 400 people, and now with the Airbus 380 you may have 500 people in an aircraft. They give you a flotation device in case you touch down in the water, and that's the extent [of the survival gear you are given]. That and your seatbelt are your safety [devices] as you're sitting in this aircraft. They also have a much greater—I call it scatter factor. They have millions of flights of aircraft throughout the 100-plus years of flight. Takeoffs, landings—they've experienced everything, so we have technology.

Because it's more routine, you can plan for contingencies and try to work out of it. Plus you have multiple engines. You lose one engine, you can still fly on the other engines or engine. You can also glide. The Space Shuttle doesn't afford you any of those things. During ascent you lose engines, you're not going to make orbit and you have to do something different. During entry, you're a glider, and if you don't have the energy to make the runway that you're shooting for, you're going to do a crash landing someplace. The vehicle is not designed for that, it's not designed for crash landings as some aircraft more or less are.

The parallels are there to an extent, but other than the fact that the orbiter has wings and does gliding entry, a lot of the environment is different. It's hard sometimes for folks who don't work on the systems to understand those differences until you sit down and explain it to them. It makes sense on the surface to look at all these systems, but when you look at what you're trying to get away from [you quickly see that the available systems don't help a lot.]

We did look at some extraction systems. There are actually seats that were used in some helicopters and some slower fixed-wing aircraft that had a rocket that would launch from behind the seat, and there's a lanyard that the crew member wears and it yanks you out of your seat basically. But again, it's slower aircraft. It's helicopters, so that's even less capability than the ejection seat. We did look at them, because they're lighter too, so if we could bail out maybe we could extract from the vehicle. But it just didn't offer enough, not nearly as much as the ejection seat, which is what we gravitated to.

I should also say that one of the things we did look at was modifying the crew cabin to make it, in one extent, an entry vehicle. If it was high enough up that it would have enough capability to go through some of the thermal environment—not all of it, not enter from space necessarily. But that was even worse as far as the weight impact on the vehicle, and it was quickly discounted because the modification was such that you needed to design that first, build the spacecraft around it. You couldn't retrofit that into the orbiter.

ROSS-NAZZAL: Tell us about testing that bailout system. Were you involved in that at all?

TEMPLIN: No, Phase 1 was going on more or less in parallel, when they decided to go with the pole system. They had a couple different ideas. They actually had some extraction rockets they looked at mounting around the crew cabin hatch that would pull the crew member out, and then they had the pole system. Those tests were going on under Phase 1, and that was worked with the military. They modified a C-141 aircraft and had volunteers sign up to bail out of that vehicle and look at trajectories. That happened in parallel with the work I was doing. I was doing Phase 2 which was trying to expand that escape envelope with more capable systems.

ROSS-NAZZAL: It's all fascinating. Did you work with [James P.] Bagian and Steve [Steven R.] Nagel on this?

TEMPLIN: I worked with Steve Nagel. He was my crew member representative on Phase 2, and he and I worked together on that for a number of years.

ROSS-NAZZAL: I know it meant so much to him. When we interviewed him he talked about that. That was his greatest accomplishment, I think.

TEMPLIN: You learn a lot. Steve spanned both programs. I was fairly new, and I looked at the responsibility I was given to lead those teams at a young age. It illustrated what my co-op adviser had told me all along, that at NASA you may not get as much money to start but you'll get the leadership sooner. Unfortunately we had a disaster that thrust people into those roles at that point.

I'm sitting on this team and I've got an astronaut, and I've got an engineer from Rockwell [International] who had 40 years of experience and was a Navy pilot, thinking, "I'm supposed to lead these people?" I remember having a conversation with Steve one time because he had flown. I look at it from my non-pilot standpoint, and I go okay, I'm doing an abort and I'm flying back to the Kennedy Space Center [Florida] on a glide. I can see the beach and the runway, and Houston radios up, says, "You don't have enough energy; bail out." I said, "You're going to see that beach and try to make it, right Steve?" He said, "Absolutely not. We train, and if Houston says I better do something, they know what they're talking about. I will follow that direction. I will bail out."

It really showed me how important it was for the engineers who design the systems and the flight directors/flight controllers who operate the missions to really have their stuff together, because those crews are relying on you. That's the way they practice, and it's the way they fly. At an early age again learning that just really was an eye-opener.

Steve was a great person to talk to. You get all kinds of different characters over there in the Astronaut Office. He was just such a good guy to work with, very easy to talk to. For the reasons you're designing a system not a good project, but a good project to be involved with because of the people that I was working with throughout those years.

ROSS-NAZZAL: What did you work on after this project concluded?

TEMPLIN: I hired into the Engineering Directorate, and I was in advanced programs. We worked a number of different things throughout that stint. One of the notable ones that I moved on to after that was something called the liquid flyback booster that Max [Maxime A.] Faget, believe it or not, had introduced to Arnie [Arnold D.] Aldrich at [NASA] Headquarters [Washington, D.C.].

It was a concept [to] replace the solid rocket boosters with liquid boosters [that] had a deployable wing. [The flyback boosters] would fly back to the Cape [Cape Canaveral, Florida], and it would be easier to restore them because they wouldn't be dropping into salt water, having to be broken into segments, and shipped back to Utah [Morton Thiokol, Inc.].

I think the initial response from folks was "That's a crazy idea. Let's go show that that's a crazy idea." I got pulled into a tiger team working for Jay [H.] Greene. … When I say tiger team, I think there were five of us working this. My job was to do the ascent performance analysis. We had two weeks to go get our numbers and show why this wasn't a good thing to pursue. "Let's put this to bed" type of direction.

The first sets of numbers I ran, and I went back to Jay Greene, "We might want to look at this. This has quite a bit of performance in it if it's buildable." This had nothing to do with the fly-back portion, this was just the ascent performance portion. Interesting to watch that we go from initial direction, which is trying to show why this is not feasible, to six months later we're making a presentation at Headquarters to Arnie Aldrich on why this is something we ought to pursue. Very interesting, got to interface with Jay Greene every day. We had a status meeting every morning with him to show what we had done the day before, leading up to that presentation.

That project was typical of a lot of engineering, you're going to introduce and be a part of a lot of concepts that never come to fruition, but the people you encounter in working on these things—it's enjoyable to work with them and definitely educational.

ROSS-NAZZAL: Were you looking at the original studies that came forth for the Shuttle program? Originally of course there was that idea that the Shuttle was going to be a two-stage [vehicle], completely reusable. Did you start looking at those studies?

TEMPLIN: Slightly different. If you look at those original concepts—we had some of the wind tunnel models in the office I worked in, where the external tank that we have today was really the core of a winged vehicle. The first stage booster was going to have enough engines and a tank such that when it was expended, it would fly back to the Kennedy Space Center and quickly be turned around and refurbished and flown. This was a little bit different; this was a modification to the current system. They weren't looking to change the Space Shuttle main engine, so the external tank needed to still be there because that's the fuel for the main engines. It was just to look at replacing the solid boosters.

We did look at previous studies that had looked at replacing solids with liquids, but not recovering the booster. That stage would just go into the ocean and be discarded. It was a modification of that more or less, because we started with some of those original design boundary conditions and then added the wing and an engine to try and get it to fly back to the Kennedy Space Center.

ROSS-NAZZAL: Why wasn't the idea eventually adopted?

TEMPLIN: It was fairly complex. We weren't losing money in recovering the solid rocket boosters, but it wasn't the big money saver that it was envisioned to be either. A lot of things factored into that. If you go back to the early '70s when the Space Shuttle was proposed, they thought they'd be flying somewhere on the order of 60 flights a year, so you were flying every two weeks or so. The turnarounds were you land, you taxi over, you throw another payload in the bay, you close it up, you stack it, you go fly again. Reality was that we weren't doing that, so the flight rate didn't support the savings you would get by recovering these boosters.

There was some thought given to just discarding the boosters and continuing to procure new segments and make it a one-way from ATK [Alliant Techsystems, Inc.]. You'd get loaded segments down to the Cape, you'd stack, you'd fly, you'd throw them away. That was the major reason, that again, you're adding complexity. You have a wing and an engine that had to start, and the flight rate just didn't really support doing that. If we ever increased the flight rate they thought they'd go back and look at that sort of thing.

ROSS-NAZZAL: Did you face any adversity from Morton Thiokol at that point, for wanting to change the system?

TEMPLIN: It never got to that point because this was an internal study. It went to the associate administrator, and the considerations were given. If it had progressed I envision that we could have, but it never got that far.

ROSS-NAZZAL: Were you working with the SRB [solid rocket booster] project or was that entirely a JSC effort?

TEMPLIN: It was just JSC. A lot of it had to do with different phases of the design. I don't hear people refer to it as much today, but they may still use it in certain circles. You had Phase A, which is the initial phase of any design project, and this was considered a pre-Phase A. Very small team. You weren't covering all the details; you were doing enough to say, "Do I even want to spend any more time going forward on this?" This little tiger team was this handful of people. Got enough information that said you can get the performance you want and more.

We had so much excess performance that it was possible that we could have eliminated some abort modes on ascent, maybe not do the transatlantic abort. If the weather was bad in Spain that day, you didn't care because you had excess margin. You could actually just do a return to launch site [abort]. So attractive features, but again when you weigh the pros and cons, you look at the attractive features coupled with the cost of designing a new system. You have to prove the new system. You had some complexity with the wing and the jet engine that you would then have to also include fuel for and do an air start. It was just deemed not worthy of further work at that point.

ROSS-NAZZAL: I also ran across a paper that you wrote about an OMS [orbital maneuvering system] payload kit.

TEMPLIN: That was actually part of the original design I did. The orbital maneuvering system, the OMS system, is the most noticeable feature on the orbiter. It's the bug-eyed pods on the back end of the vehicle, but also the forward reaction control system has the same propellant and thrusters in it. It's what you do to move around in orbit. There are two orbital maneuvering system engines on the back that actually do the orbital insertions and the deorbit burns. Those are the bigger thruster engines. Then you have a series of reaction control thrusters that do more of the fine steering.

At the beginning of that project we had a parallel project in NASA. The orbital maneuvering vehicle, the OMV, was going to fly in the payload bay. Its main mission at the beginning was to go up, be deployed from the orbiter to get the Hubble Space Telescope, and then bring it back down so it could be serviced. The scientists who conduct research using Hubble want the telescope as high up as it can get, to get it out of microgravity and to also decrease the amount of drag it sees so it doesn't come down in altitude as fast.

The orbiter is limited in how far it can go, so it's deployed as high up as it can be, but then later when you want to service it you have to be able to get the two together somehow. This OMV was envisioned as a way to push the telescope as high as you want it to go—within its limits—and also a way to bring it back down for servicing. That project was being developed, and the cost and schedule were going a little bit long and a little bit high.

If you look back in some of the original design papers, there was this thing called the OMS kit. That utilized the same tanks that were used in the OMS pods. They would go in a cradle, and it would sit in the aft end of the payload bay. You'd put them in in pairs, fuel and oxidizer, and you could have up to three pair of these tanks in there. This would then be tied into the aft orbital maneuvering system plumbing.

If you looked at *Columbia*, it was actually built with the feed lines coming to the aft payload bay. They were in place. It was the only vehicle, I believe, that was built with that in mind, because it was the first flight vehicle that came out. So it wasn't something new, it was more of an ascent performance equation.

What we did is basic research. Calling McDonnell Douglas, who built the OMS pods, to verify we had enough tanks available to build a kit. We did. They looked at the structure. Easy. It's simple structure, just holding tanks. Then could we plumb it back into the system? At least on one vehicle we could. The thought was we could modify others if we wanted to.

Then you just start looking at what could the vehicle do with this extra fuel. We showed pretty quickly that we could get to the altitudes that the orbital maneuvering vehicle was going to go to. Now you're bringing your crew with you, you could go to where Hubble was. You could service it, and you could leave it. You could actually deploy it a little higher and then come back down. I wasn't high enough to be aware—I think it may have played some role in the cancellation of the OMV. I'm not saying it was a major influencer, but it certainly did open some eyes. There was a simpler way of doing the same mission with the orbiter.

So another fun project. This is where I gravitated to, I really enjoy propulsion. That was what I liked in college, so when I did ascent performance it was looking at the fire and smoke end of the vehicle and trying to see what can we do, what payloads can be put into orbit, what can we do when we get there. Orbital mechanics are what I gravitate to.

ROSS-NAZZAL: What were some of the other projects you worked on until you went out to Palmdale [California]?

TEMPLIN: It was a lot of advanced concept work. We were always looking at what the follow-on vehicles would be for Shuttle. I remember in the early ’90s we had the First Lunar Outpost work, so I got to work early design for a vehicle to put the payloads in orbit that you’d want for deploying an outpost on the Moon.

We looked at it from the standpoint of going back to the Saturn V [rocket], the largest vehicle the United States had ever built, in terms of its throw-weight, and what kind of payload it could put into orbit. If you look at the Space Shuttle system and you look at Saturn V in terms of mass to orbit, they’re not that far apart.

If you look at the Apollo program, Saturn V had to put its third stage partially spent, plus the service module, plus the command module, and then later the [lunar] lander into a low Earth orbit. About 110 nautical miles, and it was putting well in excess of 200,000 pounds into that orbit. Not everybody would agree that that’s payload, because we tend to think of payload in current terms of things in the bay of the Shuttle orbiter, but if you just look at throw-weight, how much can that rocket put into orbit, that’s what we started with.

You look at the Space Shuttle system, and what are you putting into orbit? When the main engines stop firing, what's going to orbit is the orbiter, whatever's in the payload bay of the orbiter, the crew, plus the external tank. Now the fuel is expended, but both the external tank and the orbiter and its contents are in the same trajectory. When you couple all that weight together, you're looking at something on the order of 230,000, 240,000 pounds. Comparable to the Saturn V, so we started with that.

I used to take people out to the Rocket Park at JSC and make them stand at the front end where the command module was and look down for the length of a rocket. I go, "Just to get this command module and that service module to the Moon and back you need that big rocket behind it right there."

Things haven't advanced. Chemical propulsion is still pretty much the same. We run our engines like racecar drivers do an Indy car. They're redlining if you will. They're running them at peak performance to get every ounce we can to orbit and to do useful things with it once we get there. If you're going to put an outpost on Mars, you're not just taking a lander to the surface, you're not just taking a lightweight rover, you're trying to take habitats, you're trying to take supplies. You need to send up a lot of weight. If you're bringing it from the surface of the Earth, you're trying to bring a lot of weight.

You would rather not do that in 50,000-pound chunks. You'd rather do it in 200,000-pound chunks if you can. Real quickly you gravitate back to well, is that a Saturn V class vehicle, is it a modified Shuttle? We looked at things like Shuttle C, for cargo, where you took the wings off. It's not that we'd modify an orbiter, we would build a cargo carrier. It would look a lot like maybe the fuselage without the wings. Just carry cargo up, because you weren't trying to recover the cargo so you didn't have to reenter. Also by taking wings and landing gear off, which you didn't need, you were adding that capability to the cargo weight.

We did studies like that to try and offer up different means of getting the weights up. [NASA] Marshall [Spaceflight Center, Huntsville, Alabama] was also doing some parallel studies at that time on heavy-lift vehicles, so we were complementary. We worked on the First Lunar Outpost with that. Another fun one, another one where propulsion and orbital mechanics became involved.

ROSS-NAZZAL: Who were some of your mentors when you first came in?

TEMPLIN: I mentioned Jay Greene, really enjoyed working with Jay. Jay was and is just so technically competent. You run into people like that in this program. I know I have forgotten far more than Jay remembers on a given day. Bill [William H.] Gerstenmaier is another one like that, just very very smart person. Attention to detail is mind-boggling sometimes when you've made a comment a few weeks before and you think nobody heard that, but Bill heard it. It registered with Bill. Just good people to work with.

Those are leaders, and then there's numerous people that I've worked with, just coworkers throughout the program that have helped me learn. I was in a meeting this morning, and we were talking *Enterprise* readiness for ferry. A lot of the structural issues that came up were because I worked in Palmdale with Julie [A.] Kramer White. She is a structures expert, knows a lot about corrosion. If I had not had that tour in Palmdale and worked with Julie, I have no doubt I would not know nearly what I know now on structures and corrosion issues. Those are three I can think of offhand.

ROSS-NAZZAL: Tell us about that tour and going out to Palmdale. Was that a choice assignment?

TEMPLIN: It was, I volunteered for that. I saw an advertisement come around, and apparently they try to always get a couple of systems engineers, as they call them, to rotate to Palmdale. For those that aren't familiar, Palmdale is where the initial integration of the orbiters took place, the build. We had various contractors build sections or pieces of the orbiters and then they were all brought to Palmdale and put together.

The original manufacture of the orbiters was done at Palmdale and then subsequently that's where maintenance was done. It's depot maintenance, similar to the airline industry. At certain time intervals or cycles you have to take aircraft offline. In the case of depot, it's a major inspection. You're going to open panels up; you're going to take parts off to get access. You're going to do major inspection to make sure things are okay.

Space Shuttle system is modeled a lot around the airline industry. I think Pan Am [Pan American World Airways] was actually one of the original consulting groups with NASA to try and design the Space Shuttle system, because they knew this reusable system would need maintenance. Supposed to be every three years or eight flights an orbiter was taken offline, sent to Palmdale where it can be powered down, parts removed, and major inspections done. That was a JSC-led effort at Palmdale, and they would advertise for systems engineers who might want to rotate out and spend the duration of that inspection period with the vehicle.

I saw that advertisement, thought that it looked interesting, but didn't know how serious I'd be about it. This was an instance where having worked with Jay Greene before came into play. At the time I saw this and looked into it, Jay was head of the Orbiter Project Office in Shuttle. Did not interview with him, I interviewed with a different individual. But that individual spoke to Jay, and Jay said, "Kevin would be great for the position." So when I walked in the office and was told I had the position, it was a shock.

Another one of those fascinating things—when you come from Houston, you have some flight hardware around you, but you don't see it all put together like you do when you see the flight vehicle. You go 1,500 miles away out to Palmdale, and you have the orbiter in the bay. Two engineers from Houston and several NASA engineers in residence there would work the duration. Where any anomaly would come up, they would need to consult with the Rockwell and then later [the] Boeing [Company] engineers—this was in the days before United Space Alliance—to resolve whatever the issue was and to sign off on it when it was finally done.

So you got to see a lot of paper, a lot of traffic. You'd go down to the TAIR [Test and Inspection Record] station where they'd record NASA signatures. It was great, because the TAIR station was right at the nose of the orbiter on the ground floor. If you had any question about what was the problem that was being described, you just walked right out on the floor and went to the station. You'd find the engineer or technician who could help you find and put eyeballs on the issue. Some of these things required us to step back and get a subsystem manager back here in Houston involved and work through issues. Others were easier.

Signed a lot of paper, basically, approving things or working problem resolution. The engineer on the scene that could help relay information to folks who maybe were back here in Houston trying to work the issue. We used to have the Rockwell engineers down at Downey, California, who could drive up at times and help us resolve issues.

That OMDP, Orbiter Maintenance Down Period, was [OV-105] *Endeavour*'s first. It was and continues to be the baby of the fleet. It had flown 11 missions already at that point, and it was going through its first maintenance period. Started in summer of 1996 and concluded in the spring of '97.

Again, learned about some systems that I wasn't quite as familiar with. I was not a structures-oriented person, I was a propulsion person. I learned about structures while I was there and about corrosion and the inhibitors we have installed to try and preclude corrosion. Then when we do encounter it, what we do to clean it up and make the vehicle flight-ready again.

That was also a period pre-International Space Station. We knew that was on the horizon, and we had brought the Russians into the mix. The Russians cannot launch spacecraft that get any meaningful payload down to the inclination that we wanted to fly our Space Station on. When you launch out of Kennedy Space Center, if you launch due east, you maximize the amount of payload you put into orbit. That was our original plan for Station. The Russians couldn't come that far down and bring anything meaningful, so we agreed to increase the inclination. But as you swing further north you lose payload capability, so one way we were trying to overcome that was to lighten up the spacecraft.

That included redesigning the external tank to lighten it up, and lightening up the orbiter. We did a lot of that through changes to the thermal protection system. Having flown a few flights, we knew where we had margin, so we knew where we could reduce that margin a little bit by thinning out some of the blankets. There was a lot of removals of blankets and reinstallation of different thermal protection on *Endeavour*. All the vehicles were going to go through that, but I got to see that firsthand with *Endeavour*.

ROSS-NAZZAL: Tell us about the structural inspection and what you learned from being down there that you would apply later on when you were in Florida.

TEMPLIN: As I mentioned before, you have to remove a lot of systems to get access to others, for instance the removal of the wing leading edge so you can find and look at the wing leading edge spar. Things like that to do visual inspection. Others aren't quite so easy to get to. We had to remove tiles on the lower surface so we could remove antenna access covers, so that we could then use something called a borescope. You see it in spy movies now, and at the time it was a NASA leading-edge technology. It's a camera with a light on a flexible tube that you can put into confined spaces and record what you're seeing. That's as close as you're going to get to actually viewing certain areas in the forward fuselage and other areas of the spacecraft.

During the inspection period, the vehicle was powered down, so while you were doing the inspections you could also do major mods [modifications]. I think we took advantage of every one of these OMDPs to modify the vehicles in some way, and I've already mentioned one where we were changing the thermal protection system. Sometimes, too, it would be internal. We started out the orbiters with mechanical systems in the flight deck for the pilots to visualize. Then we eventually advanced to where you had the glass cockpit, looks a lot like the current airliners.

I think a lot of people might have been shocked—up until the early 2000s some of the vehicles had the mechanical balls and different things like you'd find in some of the smaller private aircraft, maybe Cessnas still have that. The visual that people have when you say NASA is high tech, cutting-edge technology, and if they had gotten on the flight deck and seen that they'd go, "This isn't what I thought it would be."

We put the glass cockpit in the vehicles later. It wasn't during this period on *Endeavour* that I saw this, but I later saw it on *Columbia* and others. I remember thinking, when I saw it power up, "Now the vehicle looks like a spacecraft." And you do that during OMDPs.

That was a major modification that could have been done at the Kennedy Space Center, but it would have taken up a processing facility. At that time we had four orbiters, and three Orbiter Processing Facilities. So another good reason to take the vehicle away from Kennedy Space Center was to get it out of that mix so that you weren't interfering and tying up a bay. The bay at Palmdale had all the work access platforms that you needed to get access, so it just made sense to send it up and do that sort of thing. Both inspections and major mods were done at the same time.

ROSS-NAZZAL: You mentioned corrosion. *Endeavour* was actually suffering from some corrosion at that point?

TEMPLIN: Corrosion for NASA—what we worry about makes others laugh. General [Michael C.] Kostelnik—it was called Code M for [what became the Space Operations] Mission Directorate, and code M had Space Shuttle in it—had come from the Air Force and had done maintenance on aircraft. So he had us do what he called a cross-check with the Air Force to see what their maintenance procedures were versus what we did. We started out by going to Warner Robins Air Force Base in Georgia. They have the big cargo aircraft there. They talked to us, and they had some of the same problems we were having at the time. This is the early 2000s that we were there doing this check.

They talked about Kapton wiring insulation becoming brittle. "Hey, we're having that problem with the orbiters." "What'd you do to fix it?" "Well, we completely rewired the aircraft." "Well, we can't do that. What are we going to do?" But a good exchange of information.

And when they came to the Kennedy Space Center we briefed them in on what we were doing. I remember having a presentation where we were projecting up on the wall, of course a greatly magnified picture, and we were talking about a corrosion pit that we had found on the wing leading edge spar, and we had to remedy this. For scale we had a quarter next to it, and this pit is much smaller than the diameter of the quarter.

One of the Air Force personnel was like, "You worry about those things?" We go, "Yes, we have to." Because there is no off ramp for an orbiter. When it's flying and something's failing, it usually happens quickly. It's a very dynamic environment, you're moving very fast. We plan to not fail. We put redundancy in there. We put systems that fail safely on board so that we don't have catastrophic failures where we can envision something going wrong. This gentleman had seen Air Force aircraft that had enough corrosion that if you pushed hard enough it would push through the skin of the vehicle. Well, we will never get to that point on the orbiter.

It's all relative. We work in a different environment. We had to worry about things. We did not want a stress point on that spar, so if we found just the smallest bit of corrosion we would remedy it, where they may have let something go for a while. It's just a different environment. In retrospect, maybe I'm tainted now because I'm used to working in this environment. I find things like this on my car and I want to fix them right away, where it probably doesn't need to be fixed.

ROSS-NAZZAL: Did you face any challenges while you were working out in Palmdale?

TEMPLIN: Nothing overly technical. We had some scheduling issues, we had different human interaction issues that were going on. Very few NASA people resident at one of these things. It's a government facility but it's contractor-operated. It's on an Air Force plant, and it was Rockwell. During the time I was there, Boeing was completing its buyout of Rockwell, so it actually converted in November of 1996 to Boeing. Same personnel, just changed badges. One of the individuals that I knew out there had worked for Rockwell for 30 some odd years, and the conversion happened, so he got his 35-year pen from Boeing.

ROSS-NAZZAL: Probably wasn't happy about that.

TEMPLIN: Well, he laughed about it. He had spent virtually no time actually under the Boeing flag. We worked with our contractor counterparts, but they really led the effort to a large degree. We would spend time on the floor. We wanted to understand issues because we were the direct interface with subsystem managers, the civil servants back in Houston or in Florida.

We were trying to come up with a means to make it easier for the technicians to remove the RTV, the room-temperature vulcanized silicone rubber, that is the bonding agent for the blankets, the thermal protection system on the surface. It's a red rubberized material that when it has cured is stretchy, but when it's on the surface it adheres pretty well. We had very thin facesheet aluminum in certain places on the upper surface of the wing. No grinding could take place, you'll wear through the surface quickly. We had no intention when we built the vehicle of removing vast quantities of these blankets, so here we are removing large surface areas. We've got a lot of this RTV, and we've got to remove the RTV before we can put the new blanket on.

We had these poor technicians up there using water and different agents that wouldn't wear on the aluminum to try and remove it. We saw lots of instances of things like carpal tunnel [syndrome] and a lot of folks going to the clinic, because it was just very very labor intensive. We had an agent or two that we were trying to bring on board to soften up that RTV to make it easier to come off. One of them was a citric acid based agent. You could tell when they were using it because the bay smelled like oranges. It smelled really good. We had small quantities we had brought in just to try on little surfaces.

Julie Kramer White was there with me, and she and I would go down at times and interface with the technicians because we were just curious, "Is it working? Does this help?" Some of the engineers there at the time would see us down there going "They're down there telling our techs [technicians] what to do." We weren't. We were just curious to see if it was working, because if it was working we were going to try to expedite getting more of this agent in there to help move things along. It's funny how people assume things are happening, or how when you tell the story from one person to the other things get twisted around.

I remember having to sit down with the engineers and their supervisor to explain what it was we were doing. We ended up having more or less an all hands [meeting] with these technicians and the engineers to explain the relationships. I realized during that meeting the technicians had no idea why we were doing this modification. I thought, "Hey, let's do a brown bag." If they want to come in and sit down at lunch, I'll be glad to sit here and explain why we're doing some of the modifications to the vehicle. There's a good reason to do this; we're trying to lighten the vehicle because we need to fly a higher inclination so the Russians can join us in this International Space Station.

I think it's more meaningful if you understand why you're doing what you're doing, how that's improving the system. That was something that came out of it. Definitely [an] enhancement to my career, because it helped me to understand how people perceive things, how you have to communicate and try to be as clear as you can in communication. Make sure that everybody's involved in the decision so that you don't run into those situations where people misinterpret actions. Not that I still don't walk into some of those things, but a good experience, good thing to learn from.

ROSS-NAZZAL: What were workdays like out there? I think Julie mentioned that they were running three shifts a day, is that correct?

TEMPLIN: When we started out it was single-shift. We worked early. We started at 6:30, went 6:30 to 3:30. Schedule is always a big thing when you're working missions. It seemed more [relaxed] in Palmdale because you're away from the flightline, away from the launch pad. Obviously we wanted to get the vehicle done on the schedule we had advertised, because we needed to get the vehicle back to the Kennedy Space Center to put it back in flight status.

We didn't ignore schedule, but you can start off where you do single-shift operations, and you reserve your second shift or even your third shift, which is the overnight shift, for doing things that require bay clearances. To shoot X-rays you couldn't have people around, so you would have a minimal crew come in on third shift to do X-rays or that sort of operation.

The further into the flow you got, if you saw that you were having some things pop up that were causing you to burn some of your margin on your schedule, we would go to second shift. Then the last couple weeks we were working around the clock. Trying to do everything, close out as much of the anomalies as you can. You wanted to transfer as few problems back to the Kennedy Space Center to close out as you could, as they did when they sent the vehicle to Palmdale. They didn't like to send it out with what we called "open paper," things that they started that we had to finish. And vice versa, that we would start at Palmdale and they'd have to finish. And you wanted to make the schedule also, so you had more folks on board working round the clock at the end than you did at the beginning.

I remember as the rotational engineers, Julie and I got to do the tours. Those were always scheduled in front of the flow for second shift. We would bring Lancaster [California] City Council through at 4:00 in the afternoon, and Julie and I took turns doing the tour. One would be the lead and would do the talking, and the other would be the shepherd dog in the back end. I enjoyed talking about the vehicles and liked giving those tours, because it was a chance to talk to folks who didn't have that firsthand knowledge. It was a lot of fun to give tours.

ROSS-NAZZAL: So very different from your job here at JSC.

TEMPLIN: Definitely. You can talk about things here at JSC. You can go to the Rocket Park and you can look at things we did in the past, there are vacuum chambers here, there's flight hardware here—but it's more spread out. It's harder to look at an actuator and get excited than it is to look at an orbiter and go, "That thing has been to space." Well, the actuator has been to space too, but you recognize the outer mold line [of the orbiter]. That's what you gravitate to and want to talk about.

Having that exposure to the flight hardware on a consistent basis was a career changer for me, because I've continued to want to gravitate back to that. Having started in advanced programs, which is paper studies—you're doing concepts, but they're not real and you knew that a good many of those would never come to fruition—all the way to the other end of the spectrum to where you're working on a flight vehicle that is going to space. In my case I was doing maintenance on one so that it would return to flight status, but still you felt a different connection to the program than you do when you're looking at enhancements and you're 1,500 miles away from the actual flight hardware. It's different.

So I've come back from that experience and definitely encouraged folks at every turn to try to get close to the hardware in some form or fashion. Whether it was going to White Sands [Test Facility, New Mexico] to do tests on flight hardware or [NASA] Stennis [Space Center, Mississippi]. You could do test on engines there or get around the integrated vehicle at the Cape. You can't measure how valuable that experience is.

ROSS-NAZZAL: Earlier you mentioned that this was like an aircraft depot. Would you talk about working conditions out there, what things were like?

TEMPLIN: More relaxed in Palmdale than it was at Kennedy, and rightfully so. You've got a vehicle at Kennedy and a processing facility. A lot of times powered up, a lot of activity. There's a lot of activity going on at Palmdale too, but when you power down and you're doing inspections, you don't have the distractions of being on what I call the flightline all around you.

It just feels more relaxed. There was rigor there—I don't want to make it sound like folks didn't pay attention to detail, because they definitely did. The paper processes that were instituted at Palmdale were the same as those used at the Kennedy Space Center, because the paper had to transfer back and forth.

But I went from working in Houston where I wore a tie every day, to being encouraged to not wear that tie and wear things where I could get dirty. I was going to go out on the floor, and I was going to be poking my head into things and looking at things firsthand with an engineer, with technicians. Very different. I sent a note back from out there to a coworker who asked how things were going, and I made some comment to the effect of what I was doing and going out, working on the vehicle. I say getting dirty—it was a clean environment, but you're getting your hands on. Ended the statement, "And can you believe they're paying me to do this?" Because I felt like I would have volunteered to do it just to have the experience.

ROSS-NAZZAL: So you worked in groups of three with a Boeing engineer, JSC [system engineer], and then a tech?

TEMPLIN: Your interfaces in my position were usually engineers. It would be the Boeing engineer who was a subsystem manager, and usually somebody in Houston who was a civil servant subsystem manager. But you also got to know a lot of the technicians really well, so whenever you did need to examine something you almost always had the technicians there because they gave you insights that the engineers maybe didn't have.

I would even take the opportunity when I could—not that we could ask them to do everything—to pull a tech to the side and ask them what they thought, how should we do this, or what do you think might make this system go together a little better. We had reasons for doing things in the sequence we did. Sometimes it was open for debate, but it's always good to get the insights.

I like to work on cars. I get a manual and it'll have a picture in there, and it says to put a wrench in a certain place and do something. You're back there looking at the hardware and you cannot do what the picture says. The hands-on experience is different sometimes than what you get [on paper]. This is what I was describing before. When you're 1,500 miles away and you have a drawing—I had that discussion a couple times with an engineer going, "It says you can see this." "Well, I'm here to tell you I'm looking at it now, and I can't."

That's why the technician is so important. They're the people who actually have to do the procedures, take things apart, put things back together. A lot of those folks in Palmdale at the time had been there for the build, and they had a lot of ownership in those vehicles. The way the system worked out there was that a vehicle would come in, they'd have 9 months to maybe 12, 13 months worth of work to do on that vehicle. The vehicle would leave, and there would be a gap. Three, four, five months before another vehicle would show up. A lot of them would have to be laid off and find other things to do. Where I come from that would be I'm finding another career, because I need consistency, I need to know where the paycheck is coming from.

These people came back in numbers that I couldn't believe. 80%, 85% of the people would return every time. They'd find something else to do because they wanted to work on those orbiters. They would refer to them in the possessive, that was their vehicle. They built that vehicle; they maintained that vehicle. That ownership was really something to see.

Again, another thing that changes how you view things. You get a real respect for the workforce when you're around them, and you see the pride they take in their work. It's not just a paycheck to them. They wanted to be involved, they wanted to do it right, knew the right way to do it. It was good to get their insights.

ROSS-NAZZAL: I think this might be a good place for us to stop.

[End of interview]