

**NASA JOHNSON SPACE CENTER ORAL HISTORY PROJECT  
EDITED ORAL HISTORY 4 TRANSCRIPT**

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INTERVIEWED BY JENNIFER ROSS-NAZZAL  
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ROSS-NAZZAL: Today is May 28, 2009. This oral history with Kathy Sullivan is being conducted for the Johnson Space Center Oral History Project in Columbus, Ohio. Jennifer Ross-Nazzal is the interviewer. Thanks again for making time for me all day today.

SULLIVAN: Always a pleasure.

ROSS-NAZZAL: I thought we'd start with a contemporary topic. That is Charlie [Charles F.] Bolden [Jr.], who has been nominated as [President] Barack Obama's choice for the new NASA administrator. You spoke so highly of him last time, I thought maybe you'd like to talk about his selection.

SULLIVAN: Nothing has changed since the last time we spoke in how highly I regard Charlie Bolden. From the beginning of the speculation and rumblings on the blogosphere about who might be chosen by the new administration, I frankly was hoping that Charlie might a) come under consideration and b) be willing to consider it. It's not a small consideration to shift from whatever you're currently doing to take on a service role like NASA administrator or any such presidential appointment.

As you know, there was lots of to-ing and fro-ing in the blogosphere starting probably around January 20 at 1:30 in the afternoon. I'm delighted. I just think Charlie is such a superb

package overall for the job. His personal qualities, his integrity, his character, his leadership capacity and style, his manner of leadership I think are well suited. It's a tough job. There is both the authoritative clarity of being in charge of the agency and directing things, as well as the realities of working in the congressional environment and with the White House environment. You have so many stakeholders and so many competing viewpoints. It's not a small thing at all, and I think Charlie's competencies and approach to leadership suit him to that really well. So I'm hopeful.

I'm pleased the nomination came out when the new Augustine panel was still just forming. I think in the end it serves the agency and the country better to have a designated administrator, if not fully confirmed yet, able to see and be part of and follow that process, given that it will in the end turn into some degree of his charge to carry out. I'm glad for that. I'm delighted. I think it's all to the good for the country and the agency and wish him well. He knows I'm on his list of able and willing foot soldiers any time he needs me.

ROSS-NAZZAL: We were happy to hear that. We're hoping it means good things for JSC and for human spaceflight in particular.

SULLIVAN: Yes. I hope that too, although we all recognize the charge of the administrator is not just human spaceflight. I think we're in for some interesting times, to say the very least.

ROSS-NAZZAL: Especially given the economic situation that the nation is in at this point.

SULLIVAN: Current economics will not make any of this any easier. That is for sure, yes.

ROSS-NAZZAL: You spent so much time working up all those plans for servicing missions. What are your thoughts on STS-125, the final Hubble servicing mission, as it comes to a close?

SULLIVAN: I adored watching the final servicing mission for lots of reasons. I guess I didn't feel quite the same twinge of sadness that some folks seem to feel. Hubble has had its designated service life and then some, and even the full mission run that it was set up to have, if you start the counting after the first servicing mission restored the optical performance.

I understand the nostalgia of seeing this spacecraft end, but I'm also excited by the ones that are coming in its wake. There were some obviously very fun bookends to me, being on the first Hubble flight and now watching the final one. Everything that's happened and all the great scientific and flight operations accomplishments in between just lent a nice glow to the experience of watching it.

There's a fun little personal story embedded in this last flight, part of which had escaped my memory for quite some time and was brought back to mind through Christmas card correspondence earlier in the year. I'll start at the end of the story and then back up to it. A couple of years ago, I designed, with a jeweler here in town, a variant of the astronaut pin that was a little bit larger and suggested Earth orbit. This was the kind of piece of jewelry I could imagine wearing with great delight on business suits and even formal wear. I copyrighted the design so that no one would just glibly use it, and let the folks down in the Astronaut Office know that we'd let any of the full-time CB gals [female astronauts] that wanted one have it just for cost of reproduction. Contact the jeweler or let me know.

Something around a year went by, and I finally heard back from the jeweler that they'd been contacted by an astronaut who wanted the pin. I asked who it was. He said, "Oh, it's [K.] Megan McArthur, do you know her?"

I told him Megan came well after me and I didn't really know her. Then I hopped online, dropped her an email, saying, "Delighted you've found the pin, know you'll enjoy it, and let me know if I can help in any way with the interfaces."

She quickly came back asking if my pin had ever been flown. Of course it hadn't. I told her that. She asked if I would like it to go up with her. She'd be pleased to take it on STS-125. Those personal item and memento slots are terribly limited, as you well know. This is Megan's first flight, and certainly on my first flight, I was mindful of a lot of people. So I was delighted, but frankly a bit amazed that she would offer such a generous thing. We never worked together, we didn't really overlap, so I'm thinking this is an awfully nice thing to do, out of the blue. I figured she was offering as a nice courtesy to the gal who came up with the pin; fair enough. "Yes, please," I said, and sent it down to her.

That was something around early '08, I think. Comes Christmas time, and I get a card from a friend in Virginia who used to work with the Secret Service as a special agent and aquatics guy. He collaborates with some other mutual friends on a student design engineering competition called the International Human-Powered Submarine Races. In his card to me, Jim remarks that he's going to go down and see the STS-125 launch. Megan McArthur has invited him. "You remember her," he says, "that young student that you talked with on the beach at the sub races back in 1993? The one who had wanted to be an astronaut forever, who I asked you to spend some extra time with? Boy, did you make a difference! Isn't it fun to see where this has all come out?"

I've done hundreds of such appearances, with brief counseling, and inspiration sessions on the side. I'm always happy to do them, but they do quite honestly become a bit of a blur. So I remembered being at those sub races, but any particulars about one team or one young gal had long since vanished in the blur of memory.

I laughed out loud. Now it all made sense. Now there were at least two reasons that Megan might have been moved to offer to take something of mine along on her first flight. I quickly hopped on email again and sent off just a fun, "Hey, you'll never guess what I just realized," and recapped in two lines that Jim had pointed this out and closed with something like, "a) now you've done enough of these, I'm sure you can appreciate how it could have faded into memory and been lost from my recollection, and b) I sure hope I said something useful and intelligent on the beach that day."

Her email came back like instantly. "Are you kidding? I quote you all the time," and filling in a little more of that. That was terribly fun to realize that that thread ran the way it did, and that I had played a small role. Megan was already well on the track in terms of motivation and technical skills to end up an astronaut, and I was fortunate to get to meet her at one of those moments where a bit of inspiration or a bit of confirmation could add to the equation. The rest speaks for itself, including the fabulous performance of the crew overall on the flight. So that was a very fun bookend that also ran through my mind as I watched this all go by.

I thought back to the early days, or least my early days, when I joined Bruce McCandless [II], who'd had his hand in this for a fair bit before me, and Ron Sheffield and others. We kept scratching our head and sharpening our pencils about what really is the full set of items on Hubble that one ought to want to be able to service if this thing really gets up there and starts performing. When I joined the effort and we were just eighteen or twenty months from flight,

there was a limit to what you could do. In the aftermath of the *Challenger* accident, that time window expanded. Without even much conscious discussion among Bruce and Ron and I and others, we just kept using that time to refine and deepen the repair capability that could support Hubble for a long run.

In that phase of things, we did actually think ahead and do some fair amount of preparation for the eventuality of needing to fix a Power Control Unit, which of course happened on Servicing Mission 3 [STS-109]. The level of breaking open boxes and doing integrated circuit card replacement on this last flight was another horizon beyond where we got to. So another other thing I found fun and really gratifying about [STS]-125, was that it represented both another really great confirmation of the strong foundation that all our early work had set and a new horizon to boot. We'd built a team that was very thoughtful and intentional about capturing and passing down lessons. We started that in the early predeployment phases. That's clearly been continued by Ron Sheffield and others, because the conveyed wisdom, the carried-down knowledge, the propagation of lessons learned and even tacit knowledge, has clearly been done well enough and strongly enough to support high performance by each of the subsequent servicing crews. That's very gratifying to see. We got all this started on a really sound footing, and folks have come in and kept that going.

On the other hand, as a counterpoint, it was equally gratifying to see that the team was still up to a pushing-the-frontier challenge, both from the management and the technical side. It's a real testament to the discipline, the competency, and just the mindset and the confidence of lessons really learned and ingrained to be able to continue to move the bar on what is now feasible without prior planning, without preflight on-the-ground preparation; what can you step in and say, "I need to change my mind. I now need to be able to do this. So, we can do this, and

here's how." That's a simple thing to say, but that's actually a really important capacity philosophically, culturally, and technically in an organization.

I do feel a little bit of bittersweet regret that the hiatus is coming up. The program design that's coming forward at us seem to me to pose a lot of likelihood that this very hard-won competency and capacity at spacewalks and complex servicing will be lost. I worry about that frittering away in the however many years that may lie ahead that are consumed with PDRs [Preliminary Design Reviews], CDRs [Conceptual Design Reviews], and PowerPoint meetings. Everything but bending metal, everything but actually getting out and doing the work.

My history with the program starts before STS-1, goes through the hand-wringing of the very first spacewalks and the nervousness about suits. Even in [STS]-41G when we did our spacewalk, the program was still really awfully nervous about spacewalks being very risky. You didn't have the sense that spacewalking was really a tool and capability the program comfortably used—not cavalierly—but comfortably used in a comparatively routine task. It's a tool you use. It's not a difficult scary thing you do only when you have to. The Station assembly approach pushed on that boundary. The early satellite servicing missions, we did Solar Max and the PALAPA/WESTAR retrieve. We then had a hiatus before the INTELSAT retrieve. I thought we lost some lessons within collective memory just between those clusters of servicing missions. I thought there were some glitches in the planning and preparations just by the time INTELSAT came around that to me represented a failure on our collective part to really carry all those lessons forward and keep them in active use and convey them to each other so we were progressively building.

The Hubble experience, I think it fed into and supported a lot of aspects of how Station preparations and EVA [Extravehicular Activity] cadre training was done. All of that worked

together and has really created a very robust capacity now. I just worry about that atrophying. If we're serious about doing extended zero-G work or planetary surface work, that's not a capacity I think we can afford to let atrophy, or to have it once again fade back to being infrequently used and we're a bit nervous about it. I think that has to be an integral part of the toolkit that we know we're competent at and we're smart but comfortable about using.

ROSS-NAZZAL: How do you think you can keep that up without flying the Shuttle?

SULLIVAN: I don't know. I'm not arguing to do frivolous spacewalks for training purposes, necessarily, but I just worry about bridging Station assembly. Physical Station assembly is almost complete. That'll go back to indoor sports and science, as it should. That's the right thing to do. The need for lots of EVAs in that domain is going to go away. Shuttle and EVA capacity will go down. We're going to go to a more encapsulated system if, presumably, the current architecture stays in place. The next real need for extensive suited operating experience may well not come until you're back on the surface of a planet, unless in the process of getting there you decide that you do need to use orbital flights on whatever platform as your training and preparation or for engineering tests. There are ways to do it. I think it has to start with key program officials higher up and down at the operating level being very mindful of the challenge, the concern, and acting intentionally to do what they can to avert it.

ROSS-NAZZAL: I thought we would turn to STS-31. One of the things that we didn't talk about last time was the press interest in this mission. Do you want to talk about that some?



SULLIVAN: Well, we can. My recollection of the press interest surrounding STS-31 is not a whole lot different than around either of the other two flights. [STS]-41G had a certain amount of press interest because it was still early days and a bit rare. This idea of women flying in space was still a little bit new. Two on one flight was certainly wildly new. Then we had a Canadian and another visiting scientist. There was kerfuffle around those aspects. The astronomy community's and the scientific community's interest in Hubble and what it would do post-deployment, I felt removed from. I didn't feel overwhelmed by that. I didn't really register the press interest as affecting me in any meaningfully different way.

We got down to thirty-one seconds with an APU [Auxiliary Power Unit] problem on the first launch attempt and scrubbed at thirty-one seconds. It pretty quickly became clear that we weren't going to turn around within the time span of our quarantine window so we got sprung loose from quarantine so we could go to the beach and at least visit some of the family and friends who had come all that way to see us go. The thing that was different to me about that flight was that it was the only one of my own flights where I got a sense of the energy and activity level on the beach around family and friends. Of course a huge swarm of Hubble relatives and extended family had gathered themselves, or been gathered by NASA. I don't honestly know which, but they were staying at the same hotel complex that my friends and family were at. I remember that very vividly. There was this huge whole gaggle and party over there. "Those are the Hubbles!" There's this mass of excited and eager people. Slightly disappointed that they hadn't seen the fireworks, but glad to be there for this great exciting evolution.

It's interesting that you raise that point, because that's not really on my radar screen at all.

ROSS-NAZZAL: I was curious. I think Loren [J.] Shriver talked a little bit about the press interest, not much. Loren doesn't say a lot, but I was curious what your thoughts were.

SULLIVAN: My perception was that it was not notably different, from the point of view of my role on the crew. Loren may have been fending off. I think that was also Loren's first command. So first command where you're triaging and making all the go/no-go decisions, how much exposure, how much of this stuff will I put on my crew, maybe that played a role in his sense of it. Certainly I would think there was probably more interest in Hubble than some generic cargo at that time, but I didn't have to deal with those things. We had a press event on the schedule, so we'd go to the press event. Interview rounds on the schedule, we go do the interview rounds. Back in the simulator.

ROSS-NAZZAL: You had talked a great deal about your work in California. Did you want to talk some about your work with the European folks? In particular, going over to England and working with solar arrays?

SULLIVAN: That was pretty significant and was one of the memorable parts of the preparations. The original HST solar arrays, the curtain rod ones, were designed by British Aerospace. The arrays plus contributions to some of the science instruments constituted the European share, which in turn earned them a share of the observing time. When we came to deployment, we were going to have mission control in Houston, the Hubble Ops Center at Goddard [Space Flight Center, Greenbelt, Maryland], the Telescope Ops Center at Johns Hopkins [University,

Baltimore, Maryland], and the various European Space Agency elements, some on-site at US Centers and some still back at home. A larger lash-up in that sense than I had seen on my first flight.

The solar arrays of course consisted of two solar arrays with three different mechanical functions. Unlatch them, pivot them down, and then unfurl them. All three of these had manual backups through EVA tools. I guess it would have been '89 when the solar array flight hardware was finished and undergoing test at British Aerospace Bristol.

Our approach to all these tools was, in every case, whenever humanly possible, take the actual flight tool to the actual flight hardware. This let us verify that it fit on every fitting, that all that we expected was there. We could verify that the tool extension clears the things that we were aware of it needing to clear; get a visual confirmation that the way underwater mockups are built jives with what we've seen here in the flight hardware, gather any annotation that we need to take back to the training facilities to update the training. Then there's the tactile experience of, if you actually end up out here cranking the solar array out, what does the running torque actually feel like? What are the visual observations you should be watching for? You've got the experts there that built it. They can give you commentary and cue you to the behaviors they've learned from running it through earlier tests.

That flight hardware experience is really valuable to prepare you to recognize what's expected, what's not expected, and make sure that the simulators have not been lying to you in a bad way. My operating philosophy was that every simulator is lying to me. They can't be perfected. That's a silly standard to try to set. They're inevitably lying to me. The challenge is to get very sharp and aware of where are they lying to you, and how significant is the miscue or the lie, and mentally correct for that.

Bruce and I got things set up, grabbed the tools, and rendezvoused at the facility over in Bristol. It was a really fascinating combination of technical and cultural experience. We traveled independently because of preceding commitments. I went from Washington all-day meetings onto a plane. I landed at [London] Heathrow [Airport, England] around 7:00 a.m., and they had sent a car to drive me to Bristol, because I knew I was going to be so exhausted I wouldn't dare drive. We were going to go right into a test, and I needed to be fresh.

I slept most of the way to Bristol and was taken to a management briefing room when I arrived. It all seemed very formal. I was ready to just throw on my flight suit and get out on the test floor and get at this. Instead we found ourselves in these rather more formal "welcome the flight crew" events, which I hadn't expected. Eventually we went onto the shop floor and did an initial walkthrough overview. They had the solar array suspended in a rig. It's not meant to move itself in a gravity field, so you had to orient it in the G field and suspend it so that the pull-down curtain part, the extension of the arrays out from the central spool, was essentially unconstrained by gravity. They had it rigged so that curtain rod would go sideways in each direction. I think that was the way it was set up.

We got an overview brief of all that. Again we're rubbing our hands, about ready to dig in and get the tools out and go, and they said, "Lunchtime!"

We looked at each other like, "Lunch? Let's do the test!" but they hauled us off to lunch. It was a seated lunch in, again, what looked like the management dining room, with senior company officials and linen tablecloths. To our complete astonishment, several folks were having a pint of ale or a glass of wine. I know this is more common in the European culture, but this is the middle of the workday. I remember they offered Bruce and me something to drink, and we just looked at each other in amazement—we didn't say anything out loud, but you could

tell, just by eyeball contact, that we each were thinking, “Who in their right mind would think I would have even a sip of alcohol when I’m about to go out and manipulate flight hardware? You’re kidding, right? Not in a million years.” So there were just some of those interesting “and now for something entirely different” moments.

Every other piece of Hubble we had ever dealt with was in a Class 5 Clean Room facility. Here are the solar arrays in a rather different clean room. It was a clean room, but a couple of guys didn’t have anything on their hair. Nobody was bunnied up like you’d see in a Class 5 facility, with gloves taped on and booties. It was all just rather less rigorous than certainly what I had seen of Class 5. I thought, “Well, this is interesting. We’re going to prepare this all up here and button it up, and then ship it over and bolt it onto the telescope in a Class 5 clean facility. I wonder what how that’s going to work out.”

There were those bits of comic threads that may have felt larger at the time because I was perhaps a little bit sleep-deprived, but the test went fine. It was very informative to get that feel of things and watch things. Then, of course, not too many months later one of the arrays balked during the original deployment. Bruce and I bolted down to the airlock, and Charlie came with us to button us up and get us ready to go out the door. Given the geometry of the telescope out in the payload bay at that time and the array that had stuck, it would in fact have come to me to crank it out, if the software command hadn’t worked.

I was, at that point, extra grateful for that trip to Britain, the experience that I had there. That was a very busy time. We went over, did the test, and right after the test headed back to Heathrow and came home. I remember hearing from KT [Kathryn C. Thornton] and some of the SM1 [Servicing Mission 1] crews about going over to get the training at Bristol, getting the whole Stonehenge tour, and all sorts of great things. Maybe that’s what you get after you’ve

successfully fixed their solar array. We didn't get that. We just went over there, worked, and came home.

ROSS-NAZZAL: The documentary that recently aired on Discovery, *When We Left the Earth*, made such a big deal out of your mission, about how there was a possibility that you might have used too much propellant going up to put the Hubble into its altitude.

SULLIVAN: The deployment altitude for Hubble was quite high for a Space Shuttle. I'm pretty sure it's the highest altitude civilian flight. Every time I say that, KT squints at me as if she went higher than that at some other point in time. Her first flight was a Defense Department flight, though, so if she did, she can't say anything. We were pretty high, 340 nautical miles. The standard design orbit is 160, so we're over twice as high. The altitude was driven by the pointing stability requirements of the telescope. It's a big vehicle with a lot of cross-section. You need to get it into a very low-density region, very high. Its control systems, they're all they need to be for the task they're designed for, but they're wimpy in a sense. Magnetic torquers and control moment gyros are not high impulse things. So you want to get it pretty high so that the pointing systems can keep it very still for long observations.

The year 1990 was at or close to a solar maximum year. So the envelope of the atmosphere is bigger, physically larger, in a year like that. There was a long time watching the solar activity and doing all the calculations to determine when we will actually be at a solar max. Because if we're on the down side—it's a fifteen-year life—if we're on the coming down side of a solar max cycle, then you could go a little lower, because the atmosphere would be deflating. This would give you more performance margin for the deployment flight. You'd have more

margin for every servicing flight. As the flight slipped, moved off the original 1985-86 date into the 1990ish timeframe and was being juggled around the manifest, it was a very extended period of time of tracking all of that and running calculations around various target launch dates.

The end of all of that extensive work, with a March 1990 launch near solar max, was a target deploy altitude of 340 nautical miles. When you put all those numbers together and run it against Orbiter performance and consumables, it turned that when you arrive on orbit about 50 percent of your onboard propellant will already have been consumed. So you're less than an hour into day one of a five-plus-day flight. You've got to release the telescope and back away, you've got to station-keep nearby in case there are any infant mortality failures. If one of those happens, you're going to have to rendezvous and capture again, service it, release, and back away again, then deorbit. You need margin for all of that, and half your propellant is already gone.

That's a lot lower initial level of propellant day one than you typically see on a Shuttle flight. That had everybody's attention. The artistic license the film guys took in *When We Left the Earth* was implying that in real time on the day we launched we unexpectedly found ourselves with such low fuel remaining. That's invention; it just juices up the story. But there is consequence, obviously, to working on those fuel margins.

One of them that we put a lot of energy into was how to respond to propellant leak alarms. If you've got fatter fuel margins and you get a leak alert, a first prudent step is to find indications that confirm it's not a false alarm. If it's not a false alarm, then act on it. For STS-31, just the risk that it might genuinely be a leak had to trigger action, because the risk that it could deplete fuel needed for deorbit was too high. So for any indication of a leak, we needed to launch parallel paths of action. We had to start out on the assumption that it is going to turn out

to be a leak, and that we're going to button the heck up really fast. I'd rather burn the propellant lowering my orbit than spew it out the side, so I want to quickly get ready to do a deorbit burn. It may be a complete deorbit burn, it may be a lower the altitude burn, but I need right away to be ready to do the burn and change the orbit. I might be going home right away, so I'd be starting to button up the cockpit and the cabin. Someone had better be checking is it really a leak, and what part of the tank system is leaking, so how much do we have to burn off? All of that has to get acted on in parallel.

We got awful darn good at that. For the telescope guys, the consequence was a little different. I actually tell this tale sometimes in talking about leadership, communication, and training, and what it sometimes takes to get people to see and move past mental models that they've created. If you're the telescope guy, you've been waiting more than a decade for this, and your view of the world is that the Shuttle crew is going to lift me up, hold me above their heads while I properly, thoroughly, and carefully unfold everything and check that everything is working. Then we're going to get everything perfectly positioned with the Sun angle and communications and all of that, and then we're all going to say, "Is everybody ready?" When everyone's really ready, then they're going to let me gracefully go and back away, and it'll be like a nice smooth handover of a baton at a track meet. That is exactly what we intended to do, and at the end of the day exactly what we delivered.

However, if anywhere in that little dance a leak alarm goes off, all bets are off. We spent a lot of effort trying to explain to them that, if that happens all of the niceties are OBE—done, gone, overtaken by events. "We are punching you off the arm ASAP. Have a nice time; we're getting out of there." This was just incomprehensible.



“No, no, no, no, you can’t, we need this and this.” They’d start back through the rehearsal of all the deployment constraints. Just in conversation, you’d go back and forth.

“Yes, we understand the deployment constraints. We intend to do that, but if this circumstance arises, forget it.”

“No, no, you don’t understand. You have to—.” It would just be this endless circular argument.

Finally, in consultation with the flight director and sim [simulation] supervisors and others, we scripted a full team international integrated simulation that was deploy day with a leak scenario. It’s very unlikely to happen, but if it does happen we have to be sure the team is as ready as possible and not have it risk the Hubble mission. So the telescope is up on the arm, and they’re working through pre-deploy stuff on the ground. Well, not many minutes into that simulation, just when everybody’s getting in the groove, here comes the propellant leak. They set it up to be a real one, not a false alarm, so we went into “button up and get down” mode. I think we had a deorbit burn done within twenty, twenty-five minutes. So something in the space of about an hour, the flight crew’s role in this eighteen-hour integrated sim was done. We’re gone. We’re down. We’re home. The rest was mission control Houston, the Telescope Ops Center, and Europe figuring out, “Oh my goodness, now what?” Well, they did figure it out. They worked themselves through that. They solved the problems. They regrouped.

That exercise obviously forced them to think and come up with new insights, and dig deeper into what do we understand and how can we help each other, all those kinds of things that you would imagine. That process revealed some greater smarts, some better approaches to normal ops for the telescope. So the program got two good things out of it. It got a telescope flight operations control team that had learned some important lessons that would let the

telescope mission go forward and succeed even if we had to throw it overboard and get out of Dodge, and they even learned some improvements to the normal course of business. They deployed with better operating skills than they would have had otherwise, and they were ready to cover that contingency if it happened, but it was pretty funny at the time.

It has struck me as I've thought about in years since. We had, happily, a simulation-rich environment. We could create a circumstance that forced people to actually sit at their consoles and live with a scenario they couldn't bring themselves to contemplate, and at a level of detail that would really change their practice. You could set up that constraint, and people engaged those simulations very constructively in good faith. You rarely see someone just gaming or BSing a simulation in that environment. The learning value is likely to be high when people engage that kind of exercise so genuinely. It was a humorous event at the time—still humorous, for that matter—but also a truly illuminating experience. “Oh no, you can't do that!” “Oh, yeah? Just watch us. I'd rather be safe with you yelling at me about wrecking your telescope than die in orbit.”

ROSS-NAZZAL: You did mention, and this is something that Loren had mentioned as well, that you watched the Hubble for a few days. You mentioned there might be a possibility of going back and servicing it if there were some challenges.

SULLIVAN: We didn't station-keep very nearby. The Shuttle is a comparatively dirty vehicle, plus you want to be safe enough away that there's zero collision likelihood. It would have to be intentional to go back to the telescope. The elements that needed to work, that you wanted to be

concerned about, were that both high gain antennas deployed successfully and were operating satisfactorily. That the solar arrays deployed successfully and were operating satisfactorily.

The final moving piece of this was the aperture door, the big barn door on the front of the telescope. That was closed. It had been kept closed on the ground 99.99 percent of the time, and it was closed in the payload bay. Before you opened this, you wanted to let the Shuttle and all of its propellant effluents get away. You wanted to let whatever little tenuous cloud of this that surrounded the telescope dissipate. You also wanted to let some initial off-gassing of the telescope itself happen before you opened the aperture door, to prevent depositing any contamination on the mirror, or as little as possible contamination on the mirror. So the aperture door was really the key driver. It was the one mechanical function that, under normal operating procedure, would not be known and verified before we released the telescope. You get up there, and everything is fine. Then the Shuttle comes home, and then you discover after landing that the latch on the aperture door won't release. It's latched shut, or the hinge motor won't drive. Those were the two final critical functions. If it won't unlatch or it won't hinge up, then no light gets in the telescope and you may as well not have done this.

So the door would have been the main thing that could have brought us back.

ROSS-NAZZAL: What did you do between deployment and landing? Were you in charge of any experiments?

SULLIVAN: We did not have a lot of other experiments aboard, just because the combination of upmass and altitude that we needed to reach really pressed the performance. Hubble itself effectively totally filled the payload bay. It's not like you had a lot of room. We had room for a

cargo bay IMAX camera and a little gas can on the aft port sill, but that was about it. I don't think we had anything in the cabin other than DSOs [Detailed Secondary Objectives]. I'd have to go look at my payload log. I don't even remember something any other of payload class. Smaller experimental objectives of the DSO class is all that I remember, mainly with us as test subjects. Bruce and I were test subjects on the intraocular pressure experiment, tracking that through time. We were higher than many crews, so we had some additional more sensitive radiation dosimetry type measurements to check the shielding. Just take more measurements inside the Shuttle cabin with that radiation exposure, that sort of thing.

We had a Linhof camera. Bruce came up with this idea. It was an interesting one. Since we were going to be in a pretty stable orbit, mowing the lawn for those days in a relatively stable consistent attitude and because we didn't have pointing constraints, we took the Linhof camera, mounted it in a bracket in W1, W2 so it could look pretty well straight down. We did swaths for the Earth observations guys. Contiguous swaths across all the major continental areas, because any image frame would cover a larger area at twice the normal Shuttle height. We figured we should take advantage of that and help fill in some of the gaps that they get in the point-and-shoot observations that are more typical of what operating crews can do. That was kind of it.

ROSS-NAZZAL: You mentioned that you were the IMAX operator, I think, last time, but that you weren't able to operate it because you were in the airlock.

SULLIVAN: Neither Bruce nor I was the primary IMAX camera operator for just that reason. If we'd been out doing spacewalks, you would have wanted to record the spacewalks. I'd operated IMAX on my first flight, not the cargo bay-mounted, but I'd been fully trained on the camera,

even the film changing and stuff that wasn't relevant for 31. I think I trained. I think Bruce had trained on it before. We all got some training on it. That really would have been Charlie and Loren commanding it on and off. That's all you can do. You set the f-stop and command it on and off through a little hand controller. That would have been the prime thing to do for any of the key deployment and other scenes.

The one time I really stepped into the fray was after deployment. They wanted a specific shot. They were aiming our footage towards two films. One they had already envisioned, a film about Hubble, that became *Destiny in Space* so they needed that footage. Plus they were trying to fill in some final gaps in the storyboard for *Blue Planet*. With our high altitude and cargo bay-mounted camera, we could get some great overview shots for them. That was our main assignment for *Blue Planet*, a couple of key regional framing shots, a great limb of the Earth; one is the great Caribbean panorama. That's a 31 shot. The particular gap they had in the storyboard for *Blue Planet* was that they didn't have a good shot of any of the great mountain ranges. There's several you could have, but the preference they expressed was to have the Himalayas. We were the last guys that were going to film for that. It would have been Himalayas first or Andes second, probably just because of the prominence of the mountain ranges and the snowcaps.

They had found one pass that was the only time our orbital geometry gave a shot at the Himalayas. We were at 28.5 degrees. The Himalayas were going to be north of us. We had the rollover point of the orbit looking right up at the Himalayas. The problem was it was smack dab in the middle of our sleep period. They're not allowed to task anybody in the sleep period. The editor, Toni Myers, who I'd worked with on the first flight and had up a social rapport with, took advantage. Not undue advantage, but used that to her benefit. She sidled up to me during the

training sessions, sketched out this problem, and said, "I don't know what to do about this. Is there anything I can do about this?"

I said, "You have just done the only thing you can do about it. Understand?" "Got it." We took the map out. We looked a little bit. "Okay, got it. This is all you can do about it. I'll do what I can. That's the only commitment I can make. You're not allowed to hold any of us hostage or beat on our heads if it doesn't work. Don't say a word to anybody. You didn't task us. We can do what we want voluntarily in our sleep period. I'm willing to give this a go, but you don't get to beat up on us if something doesn't work out." Fine. That was all good. She appreciated that. The problem was she needed to know if we got that shot. That was going to be like the third night. We had maybe two more days in orbit. If we got that shot, then she would go one direction with the rest of her film usage. If we didn't get it, she would take a different pathway. It would matter pretty quickly. Do I have this shot or not? She said, "Well, since I'm not allowed to have asked, how are we going to do this bit? How am I going to know?"

I said, "Tell you what. Flight day four, when you come on shift, if you hear me say or if Payload says, 'There was a great pass over the Himalayas last night,' that will mean I got your shot." We left it at that. I woke myself up during the sleep period. I was sleeping on the flight deck. It was very interesting. I went mentally dyslexic a bit about the viewing angle. We're inverted and the camera is pointing up out of the payload bay and the horizon is here. [Demonstrates] Now I'm trying to envision more carefully how much of the snowcap and how much of the darker background will be in the frame. "What f-stop do I need to set this at? Boy, I hope I set this at the right f-stop. Oh, well. I think it's f/11." Set it up and shot it. It was pretty forgiving broad latitude film. It all worked out fine, but it was one of those is it this way or is it

this way dyslexic things. The camera is pointing this way and the Orbiter is pointing—oh my goodness, “Shoot the scene! Shoot the scene!”

ROSS-NAZZAL: It ended up being in the film?

SULLIVAN: It ended up in the film. I always have fun when I watch that. I like the film in general. There’s this wonderful lead-in narration about, “And the great Himalayas.” This whole little story of Toni skulking around trying to figure out how to get the shot and our code phrases back and forth through mission control all comes to mind every time I see that.

ROSS-NAZZAL: I’ll have to check it out. I was thinking, in comparison to your first flight, this flight had fewer crew members. There were only five. You had seven on your first. Was there any major difference that you noticed other than there was more room?

SULLIVAN: A whole lot more room. Meals and everything went by more quickly. It was easier to get that organized. It was not a big deal or a huge inconvenience to have seven. That all worked fine. It was interesting to have a bit more room. We ended up with about the same amount of clutter. You unstow so much gear for any such flight, and we had a full EVA set up in both cases so the general operating environment wasn’t notably different. We did not have an in-cabin IMAX camera. That and all the film canisters and changing accessories was like having at least a half an extra crew member on the seven-person flight. Not having some equipment of that scope around routinely deployed was about as noticeable as not having the seven people around.

Not really a big deal. I think all of the crews that I was on interacted well enough, communicated well enough, built such strong shared awareness of the whole flight plan and the interacting parts of it that the orchestration, whether through meals or through the head in the morning—it flowed. It worked smoothly and just went without a hiccup, whether it was five or seven. On my three flights, it was seven folks, one single shift, five folks single shift, and then seven folks split shift. I noticed the seven folks split shift change more, because it was different to have so few people on the flight deck through an entire shift. It was different to have two such different things going on. You're eating, doing your notes, or marking up your flight plan, while other guys are working. So two different realms of experience, and then combine them in stories rather than everybody largely in the same flow of experience, that was interesting. "What are you guys doing down on the middeck? Never mind, never mind." Whole separate things could be happening on your spacecraft, which had sort of not really happened in the same way before.

ROSS-NAZZAL: I just have to ask. I know that you're probably going to say no, but for this mission you're the only woman on flight. Any differences?

SULLIVAN: No. I was the only woman on my third flight as well, and it was really a complete no big deal either way on both flights. Again, I think all the individuals on all those crews, to first order, we were of the same general mindset and comfort level with respect to issues of privacy. People have to change clothes. People are in the head. It was just kind of a no big deal. Nobody felt a big compulsion to say, "Go into the airlock if you're going to change your undies." Those were just nonissues. On one of the flights I remember—I guess it might have been [STS]-45, where it was just a little more crowded, and again one group would be working while one was



changing or doing presleep or postsleep preps. It was completely just an aside of no real consequence. You'd hear someone say, "I'm going to change my drawers now" or "I'm going to change my shirt now." It was as if that announcement created a sufficient bubble of privacy and was just enough of an alert to "I'm taking a private moment." No one did anything very overt. It's not like everyone fled the middeck, but it was just that easygoing, that mutually respectful, that matter-of-fact, and that much of a nonissue.

ROSS-NAZZAL: I just had to ask. We have so many people that have so many questions for us.

SULLIVAN: Well, no claim there that the way it worked out on my crews is everybody's way. The astronaut corps, especially as it becomes more heterogeneous and international, it's not all uniform. Someone might feel more particular about privacy, so maybe they do use the potty screen or the airlock as a bit of a changing room. Fine. That works pretty simple. It's not a big deal. Pretty well do what you needed to do. Again, maybe some crews tease more or jostle each other more and poke at that. The crews I was on, if you announced, "I'm going to change," or if you felt you needed to go into the airlock, there was nobody on any of my crews that would have played gotcha games or joked with you that way. Couldn't have been that consciously programmed, but it was a pretty copacetic group from that point of view.

I told you the story of when Dave [David C.] Leestma and I were first doing our suit-up training in 41G. Did I tell you that story in the trainer?

ROSS-NAZZAL: I don't remember that one.

SULLIVAN: It's this exercise during EVA training, where they stowed the one-G trainer fully. The middeck is fully accurate with respect to all your locker labels and then all the EVA stowage. Everything of your EVA stowage is there as it's going to be in flight. EV1, EV2, and the IV [Intravehicular Activity] guy go out, and you start with the day before preps. You time-compress everything, but you go from initial unbuttoning of the airlock to staging the equipment the day before. You walk through the cabin depress procedures. You do every single thing of the EVA timeline from the very first preparation step to the final restowing of the gear to come home. You time-compress it all.

In the middle there, you reach the point where the checklist says, "Don LCVGs [Liquid Cooling Ventilation Garment]." Dave and I are both standing there in slacks and shirts. It's Dave, me, Jon [A.] McBride, and three or four EVA trainers, all of whom are male.

ROSS-NAZZAL: I don't remember this story. It's not ringing any bells.

SULLIVAN: I remember we pulled the LCVGs out of the locker. I recall Dave standing on my left. I'm standing here. We're just facing the lockers. There just suddenly is this notable pause and notable silence. I have this fleeting sense that everyone has just realized that we're about to go boldly where no man has gone before—there's a woman in this mix. You have this sense that every trainer there is going, "Okay, so I always knew how this worked when it was just guys in the locker room and they peel down to their skivvies and on we go. What happens now that she's here?" Blank. No idea. So I looked over at Dave and said, "Dave, let me tell you my philosophy about modesty in circumstances like this." He shifts a bit and says, "Okay." I said, "I have none." He said, "Fine." We start peeling off clothes. The trainers dove out of the

mockup head first. We got in the LCVGs and said, “You can come back in now.” That was just how we seemed to do things on our crews. “Good. Right. Never mind. Let’s go!”

ROSS-NAZZAL: Probably worked out better.

SULLIVAN: Yes.

ROSS-NAZZAL: This mission was using a new system of brakes. There seemed to be an almost longer landing pattern. Any recollections in terms of landing?

SULLIVAN: No, nothing stands out. Other than you remind me of the other bookend that I chuckled about with STS-125, because STS-31 launched from Florida of course, and had a weather wave-off and landed in California. I don’t think we got an extension day. I think it was just a couple of revs’ wave-off, and we landed out there. So I thought it was intriguing that the very first Shuttle flight and the very final Shuttle flight to Hubble both waved off for weather and then ended up in California.

ROSS-NAZZAL: Any major differences you noticed?

SULLIVAN: My first and third flights landed in Florida, the middle one in California. Not a huge difference. The mini-moment of thanks and press at the landing site before you get on the airplane to go home stands out more on the Edwards [Air Force Base, California] landing than the final flight. I really don’t recall a post-landing, pre-Houston media moment on 41G. I recall

runway to crew quarters to airplanes and home, and all the media was in Houston. So the second flight's landing site events stand out more, because it's unusual to get to Edwards. Edwards, of course, is manned up to deal with this, but it's a pretty big deal for a Shuttle to actually end up there. There was a little mini-moment on a bit of a platform of saying some thanks.

In the STS-31 countdown, we had a problem with—I think it was the inboard fill-and-drain valve on the ET [External Tank] that was showing that it had not closed. This cropped up around the nine-minute hold. GLS [Ground Launch Sequencer] software sees that and sets a flag, so the countdown clock stops. This was on the second launch attempt; an APU malfunction scrubbed the first STS-31 launch attempt ten days prior. We sat there listening to the loops of the Launch Control Center [LCC] as the propellant and main engine guys are sorting through the different parameters that they can see in that crisp cadence. It was a fabulous thing to listen to. It was just absolutely amazing. Absolutely crisp, absolutely together. NTD [NASA Test Director] is talking to the guy, “What have you got? Where are we?”

You'd hear the launch controller thinking out loud, “I see X, but I see Y also. I see A, but, I see B. Therefore I conclude it's a false indication, and the valve is fully closed.” There's another explicit question from NTD. “Is that your firm conclusion? Are you prepared to override?” “I'm prepared to override.” Then you hear the controller go through his steps. “I'm issuing the GLS override, MARK.” NTD just (claps) says without even missing a beat, “This is NTD. Pick up the count on my mark. Three, two, one, MARK.” The count starts again and (claps) off we go.

We radioed down to the mission management guys, “That team of people needs to be at the landing site when we come home, because there wouldn't be a landing if there hadn't been the launch they pulled out of the bucket. Those guys need to be at the landing site, because this

whole mission went off because they were sharp, on the money.” Sure enough, somehow somebody arranged that those couple of launch controllers were out at the landing site. It was really pretty cool to look out over the audience at two key people and say, “Thank you for making sure this happened the right way, for the right reasons and safely.” Tough call, tough call, got to be made quickly, got to get it right, and they did.

I asked someone to get me the tape of the LCC loops from that event, because I love to witness those kind of really crisp moments of absolute expertise in action. Big risks, tough issues, a lot of data to fuse, the world is about to be moving at 17,500 miles an hour—we’re fundamentally dealing with bombs. If we do this all right, it’s a fabulous dramatic spaceflight, a tremendous scientific accomplishment. If we do just a few things even slightly wrong, people die. You’ve got to make the call, and you’ve got to make the call now. Teams of people that can come together and do that, and those microcosmic moments—“GO for launch” calls, “GO for deploy” calls, things like that—those are just pretty amazing things to be a part of. That tape’s one of my favorite souvenirs.

ROSS-NAZZAL: Very soon after you guys returned, they noticed that there was some trouble with one of Hubble’s mirrors. What were some of your thoughts when you heard that?

SULLIVAN: Unfortunately it was with the primary mirror, the big one. I had already been assigned to STS-45 when we learned that. So even before that, immediately after our core debriefs were done, I was already jumping in with the ATLAS [Atmospheric Laboratory for Applications and Science]-1 training team. Actually, I had done a couple of evolutions with them before we launched on 31, just getting things organized and moving forward. I was

payload commander. We had the PSs [payload specialists] and MSs [mission specialists] assigned, but hadn't yet added in the rest of the crew. That required me to detach from the Hubble story pretty quickly and go off and get buried in the ATLAS-1 story. Bruce stayed much more closely engaged in all that and was able to support the tiger team that came together to start figuring out what on Earth can we do about this, or, more appropriately, what off of Earth can we do about this.

I remember hearing it on the news and just being flabbergasted, just worried and disappointed. Not for myself, and not really for our crew, but the entire story and all of the planning and effort and scientific potential and everything else that had already been invested in getting to the point of having the telescope in orbit. It had been decades since 1949, if you want to start counting when Lyman Spitzer [Jr.] first thought about it. To have all of that work, and all the persistence and perseverance and dedication it had taken to culminate with an astoundingly complex and gorgeous vehicle in orbit that couldn't see right was just heartbreaking.

I followed it through the news and the technical sources that I could get at through the agency. The first little bit of heart I took—and this part seemed to elude the press and the general public—was that it didn't completely incapacitate the telescope. It was a severe problem, and it really would have compromised severely the telescope's scientific production, but the telescope wasn't dead. It could still perform at close to original performance specifications on targets that were sufficiently bright. That really reduced tremendously the range of things that Hubble could have done and, quite critically, it probably would have made impossible the deep field and Hubble constant studies which were at the core of some of the highest priority scientific objectives. But there was some good scientific productivity coming out earlier than many people recognized.

I was only able to vaguely track from afar the progress of the regrouping team—the “what do we do now” team. I was delighted, of course, when Bruce first told me they thought they had figured out a reflective optics correction, because, my God, they went through everything. Well, the first thing they did was set the rule: “No one laughs, no one snickers—anything anybody can imagine goes up on the wall. Then we’ll start doing puts and takes and combining and rejecting and so forth.” It ranged from the “wildly impossible and violates the laws of physics besides” to “you have just got to be kidding me.” I mean things like “We’re going to send astronauts down the barrel of the telescope with polishing rags and reshape the mirror.” Throw everything out there. As they worked through it all, they realized, “The bad news is you did indeed screw up the mirror by an amount that is significant and should be avoidable in figuring astronomical mirrors. The good news is you screwed it up very precisely.” This meant you knew the actual mirror shape very precisely and could do a precise difference calculation of the actual versus the desired and determine the needed correction out of that.

When they realized that and figured out that you could correct that via reflective lenses instead of transmissive ones—I don’t have to make all the light come through a lens, I can bounce it off of several mirrors and, through a couple of steps basically restore it to the focus that it should have had—that just struck me as fabulously clever. Finally, to figure out a way to engineer an optical bench that can unfold a set of small arms and position the mirrors precisely enough to do that correction, and that can be built inside of an instrument enclosure—that was just cool.

The engineering behind the COSTAR [Corrective Optics Space Telescope Axial Replacement] was just fabulous. Absolutely wonderfully clever. I followed all that very keenly, but from the distance of being busy on the ATLAS flight. ATLAS flew in April ’92, and SM1

flew in December of '93. All of those final ramp-ups and preparations were being done while I was busy with my own final flight and then transitioning to Washington. I followed them rather at a distance. Except for, obviously, following the servicing mission very closely, and being thrilled at the success and the validation of all the servicing and repair procedures and tools that were taken along with it, which was personally gratifying.

More importantly, it was confirmation that we really had set up the kind of robust, accurate and reliable platform of knowledge, tools, and procedures for the telescope teams to build on going forward, and that was what mattered most. That was a pretty extensive bunch of repairs, and it really gave me great confidence that we had built the quality of foundation that we had aimed to build. We had succeeded in doing that.

ROSS-NAZZAL: Did you have any chance to go on any PR [Public Relations] tours, or were you pretty busy with your next mission?

SULLIVAN: I didn't do very many PR tours. We were rolling in pretty fast because it was a multipayload Spacelab flight. One that had been delayed. It was the reflight of Spacelab 1, in a sense. I joined that effort, I probably joined it for real, fully, in late April early May of '90, and we flew in March '92. That's a pretty quick turnaround for bringing a Spacelab crew, all the international linkages, and science teams back up to speed.

ROSS-NAZZAL: Talk about that. You were the payload commander. For people who don't know what that is, tell us what it is.



SULLIVAN: Payload commander had a couple pieces to it. Payload commander was the NASA mission specialist who would oversee and organize the typically two mission specialists and two payload specialists who work back-to-back shifts operating complex multiexperiment Spacelab flights. I think several factors went into conceiving of the payload commander role.

One is you've got a very complex Spacelab mission with a dozen to three or four dozen experiments. The training time that the responsible mission specialist should put into that needs to be longer than the pilot and commander probably need to put into the basic orbital operations. So you're going to want to slot in mission specialists eighteen, maybe twenty-four or thirty-six months in advance so they can build the relationships that are necessary with the scientific team and the payload operations team, get out to the factories, laboratories, engineering facilities, and see the flight hardware. To the degree that the mission simulations are going to represent those payloads—sometimes they do. Sometimes it's built into the Shuttle Mission Simulator. Sometimes the preparation is done differently. The payload crew is going to play a really substantial role in helping the simulation teams know how to model the payloads correctly.

To provide a long lead time for the mission crew, to be sure that one of the NASA mission specialists is considered and recognized as authoritative in all those early planning decisions, you want that group to be able to make effective decisions and move the flight preparations forward, not have various people on the team saying someone doesn't have the authority to do this or we need the commander to make this final decision. Naming a mission specialist as payload commander gave that authority. You're also counting on that person to use smart judgment when different payload operating or crew issues do impinge on larger flight ops constraints that do eventually need concurrence by the flight director or by the commander. You're not going to step in and overrule those or supplant those. You need someone who's

representing CB [Astronaut Office] and JSC and able to keep the ball moving in those early lead phases. Help the payload specialist folks who sometimes have had prior flight experience—one of our payload specialists had flown before—but often this is their first time. Giving them some guidance about, “This is how it’s going to get done,” or, “This is the way things normally go.” Being that training voice about life aboard the Shuttle, with some authority backing that up.

That was the whole idea. Later, closer to launch, when you combine the payload crew with the Shuttle crew, that balance shifts around. The Shuttle commander is the Shuttle commander, there’s no two ways around that. You help the commander in that sense, because you know the mission teams. You know the experiment teams. You have a little more insight about the personalities, cultures, backgrounds, mindsets that the payload team brings to bear and can help jump-start the overall crew’s understanding of that by the time investment that you’ve made. That was the idea behind it.

I got slotted in with Mike [C. Michael] Foale on his first flight. At the time, Byron [K.] Lichtenberg and Mike [Michael] Lampton were going to be the payload specialists. Let’s see, that would have been, like I said, May ’90 pretty well I jumped in. I think I knew I was on the flight from something closer to January of 1990, somewhere in the first quarter of the year. Charlie, Brian [Duffy], and Dave Leestma, the flight deck crew, got slotted in somewhere in 1991, I think. It might have been as early as very late 1990, but I recall it being more like early, mid ’91.

This was a payload that had been promised as a reflight to the Spacelab 1 guys. That reaches back to 1983. It had then been bouncing through all the different remanifesting exercises for quite some time. They’d been trying to keep the experiment teams together and keep some connective tissue across the team and keep things moving along. Now we really seemed to have

a track towards a fixed and firm launch date. So that was that challenge. Get Mike and me into the game, start us up to speed, and see where are all these procedures stand, that have largely lain untouched and not been frequently exercised for almost six, seven years. Get that back up to a more proficient footing and see were we really ready to intersect it with the Shuttle team. There was a lot of time at Marshall [Space Flight Center, Huntsville, Alabama]. All the Spacelab simulators are at Marshall. I was spending most of my time going back and forth to Marshall and learning the experiments and the payloads.

We had spectrographs and a couple of in-cabin experiments that complemented the ones mounted in the payload bay. It was jump right back into about a dozen instruments and prewritten procedures. The Spacelab guys had taken a fundamentally different tack on how to structure and organize checklists. We combed through those and reoriented them to align more with Shuttle approaches just to help lower the risks of misunderstandings across segments of the flight team. Off we went, finally.

ROSS-NAZZAL: Would you describe the ATLAS payload itself and what it consisted of?

SULLIVAN: I'd have to haul out one of my reprints to remind myself of all the instruments. This was a Spacelab pallet missions, so we did not have a pressurized module out in the payload bay. Again, were going to have seven folks working on the flight deck and middeck. The difference here for me was that we were going to split up into shifts so that we could do twenty-four-hour operations. There was not enough automated interface to operate all the experiments from the ground if you put the whole crew to sleep at the same time.

We were going to go with Dave Leestma, Mike Foale, and Byron Lichtenberg on one shift, me, Brian Duffy, and at the time Mike Lampton on the other shift. The idea there was Byron had flight experience and of course Dave Leestma had flight experience. Mike was a rookie. We had experienced Orbiter crew and experienced payload crew, and that was the Red shift. Charlie of course, you don't put the commander on a shift, the commander does what he wants to do, but Charlie was going to favor towards the Blue shift as his main operating shift, because that worked properly into the landing timelines. Brian was the PLT [pilot], and so he'd have the extra backup of his CDR [commander] being around. I had flight experience. Mike L. hadn't, he'd been a backup on Spacelab 1.

We moved towards flight somewhere around—this must have been Christmas of 1990. Mike Lampton got life-threateningly ill and had to be taken off the crew. That moved consideration to the two backup payload specialists. One was Dirk [D.] Frimout of Belgium, and one was Rick [Charles R. Chappell], from Marshall. Who had both stayed with the team since Spacelab 1 days. The Spacelab guys made the decision after some months. We did a little bit of a cross-evaluation. "Let's start feeding both of them into more simulators. Everyone take a look at them, bring them up the curve a little bit, and see if we find any grounds in performance that argue one way or the other." Both very competent. There wasn't really any high level distinguishing factor there. The Spacelab team went with Dirk for the prime, for Mike's replacement. He was going to be with me on the Blue shift.

The top priority experiment was one called SEPAC, and that was something like Space [Experiments with] Particle Accelerators. It was about the physics and plasma behaviors of the space environment. It was really cool. We were all pretty jazzed about this. What this thing

was, it was basically an electron gun. In a sense, a large capacitor in the payload bay that would build a charge up to a certain level and then release a bolt of electrons.

The idea was to have the Orbiter oriented so that the aperture of the instrument would inject these electrons roughly along the magnetic field line down towards the atmosphere near the polar regions. You can think of it basically as a dose-response experiment. In medicine or other experiments, you put in a dose, you see what happens. Dial the next dose up or down, and see how the response varies. The idea here was to try to better understand the physics behind auroral phenomena by injecting a known dose of electron energy into the upper atmosphere. Then with a camera out in the payload bay and one in the cabin, measuring the brightness of the aurora type glow that that dose of electrons induced. If I know I put in this many kilovolts of energy, and I measured that luminosity, maybe I can start to get a clearer understanding of how the energy of the incoming solar particles couples into the atmosphere and creates auroral luminescence.

That was pretty exciting. It had failed early on Spacelab 1, and so this was a prime driver for the reflight, one of scientific life's tragic little ironies. An experiment like this takes electric power from the Orbiter into the pallet and then distributes it to the different experiments with an electrical bus on the pallet. There's a fuse, of course, between the Orbiter primary payload bus and the pallet. If really dumb stuff happens on the pallet, the fuse blows and the Orbiter is protected. There was also some fusing within the distribution bus on the pallet, in fact, which probably came from all the littler experiments saying, "If this sucker fries, it'll kill all of us." They probably insisted that NASA fuse SEPAC so it doesn't take all the rest of this down. I might be recalling the rating of this fuse incorrectly, but I think it was like a twenty-amp fuse between SEPAC and the other. It was fifty amps between the Orbiter primary payload bus and

the pallet, and I'm sure it was a lower rating, like twenty amps into SEPAC. We, to a one, all squinted at the European guys and said, "Oh, isn't that awfully low?" They sort of agreed it was awfully low, but the fuse was buried deeply enough inside the housing unit that nothing really was to be done about it. Hold that thought. It comes back later.

So there was SEPAC. There were a couple of spectrographs measuring solar spectra at different altitudes and latitudes, via solar occultations. The instrument would acquire the Sun far above the Earth. The Sun has a known spectrum. You're measuring that spectrum. As you go around the Earth, what happens is that the Sun effectively sets. The Sun disappears behind the Earth because you're moving away from it. As that geometry changes, your line of sight to the Sun effectively knifes down through the atmosphere, so you see changes in the spectrum of the Sun in every second that you're sampling that amount to measuring the composition of the atmosphere at all those different levels. Fun clever stuff. It was particle physics, it was atmospheric composition, that was the suite of them, and I won't remember the whole list of experiments off the top of my head. SEPAC was the biggie.

The complexity in the cabin was we had a handheld camera with photomultipliers and different filters that was the adjunct to SEPAC, and you wanted to get auroral photography, Earth limb photography, and shots of these patches that we had fired the electron gun into. That became a pretty elaborate ensemble of dark shades so you could shield the window, not have any glare, get yourself all dark-adapted, stack up all these filters and diffraction gratings, and get these photo observations. It was still photo. We were still talking photo observations back then. We're talking film and film changes, just complex photographic assembly and disassembly.

SEPAC was going to fire, finally, a day or so into the flight. The first firing was going to be on the Red shift, not long after they had taken over. Us Blue guys were all down below

mucking around with dinner and starting to get changed for sleep. We knew it was coming, and we were eager to see it, but we thought we should get out of their way, let them get set up for this, and get into it. It's the first of several firings. Some will come on our shift. We're all going to want to see this. So we're staying out of their way, being considerate crewmates. We hear them going through the checklist. Then we hear this, "Oh my God, look at that!" and four other bodies come flying up to the flight deck. There's a cardinal rule on spaceflights, or at least on all my crews, which is "there shall be no sentences from the flight deck ending in 'that,'" as in "What the hell was that?" 'Cause you'll terrify the guys down below, who can't see anything. So they had violated that rule and had all four of us come flooding up to the flight deck just in time to see.

The SEPAC looked like—out in the payload bay it would remind you of a house paint canister. You could see a little bit obliquely into the top of it. It's about to go into the second firing, there are now seven noses pasted up against the window. This odd blue. It felt like I'd stepped into a science fiction movie. This oscillating blue blob is accumulating vaguely in and around the can, as if some luminescent blue creature is about to ooze out of this can. It's getting a little brighter and larger. Then suddenly this parcel of blue energy leaps away from the Orbiter, just jumps out of the can. You actually could see it—obviously at the speed of light, so it goes by quickly. It was starting to curve away. You could see the curvature of the magnetic field line. You could just see it begin to spiral along, like all this material you drilled into your head in college physics you're now seeing in front of your eyes: the curvature of the magnetic field lines, the electron gyroradius as this thing spirals around it. "Wow, fabulous!" Then the fuse fried.

ROSS-NAZZAL: So it was the end?

SULLIVAN: End of SEPAC! They got like two or three doses off. We all each managed to see at least one. We joked around a lot, and I still joke sometimes, that I'm sure we are the only Space Shuttle crew to ever fire photon torpedoes, because that's what this was. It was like firing photon torpedoes down towards the atmosphere. Then it died, and we were distraught.

ROSS-NAZZAL: How disappointing!

SULLIVAN: Oh, it was terrible. It was terrible. We told them it was the wrong fuse. Our photon torpedoes were much better than George Lucas's photon torpedoes.

ROSS-NAZZAL: This as I understand it, was the first Mission to Planet Earth.

SULLIVAN: The first Spacelab Mission to Planet Earth.

ROSS-NAZZAL: Oh, it was the first Spacelab Mission to Planet Earth.

SULLIVAN: Yes, the whole Mission to Planet Earth Program thrust had already come out. It was somewhat teed up by the Paine Commission report, really crystallized and taken by the agency I think first in Sally's report, the Ride Report, in the rather early days after the *Challenger* accident. Remember, this mission actually had been planned and committed as a reflight back in 1983. This was not a mission originally conceived of as a Mission to Planet Earth, but the nature



of its scientific work really genuinely did align with the purposes of that new program, which was gaining momentum and clarity. That was appropriate, but it was a late addition of a moniker.

ROSS-NAZZAL: Your crew, as you pointed out, was broken up into two shifts. Was there any competition between the two teams?

SULLIVAN: No. No, there really wasn't. Not really. None of us were really of that sort of personality, "Got to prove to the other guy." I was just looking around to see if I had any of those reprints. Charlie didn't ever really use a device like that to drive performance. Commitment to each other, commitment to the mission, the intrinsic factors that he exemplified and reinforced. You want to do right by the mission. You want to do right by the opportunity you've been given. You want to certainly do right by, live up to, and deliver on the expectations of a leader like Charlie. He wouldn't have needed to set up some fake game for me to make me do anything better.

ROSS-NAZZAL: One of the things Charlie pointed out in regards to this mission that he did that was unusual, I think, was that he had the crew participate in some sort of Myers-Briggs or personality type testing. Did you find that helpful?

SULLIVAN: I actually did. The operational psych guys I think always made that option available to commanders if at any time they felt that some better understanding of a crew member or the whole crew would help make sure that there was good cohesion and group performance. We

were going to fly two out of four guys who'd been sitting around for a decade waiting. We had a four experienced Shuttle crew members and three rookies. Quite a different mix of folks around. I think Charlie knew he wanted to look at everybody to have a sense of how best to move them and drive them, support, encourage, and propel them, and suggested to us all—and it was a suggestion, and I think we all felt fully free to say what we wanted, not have to go along. We were all going to take it, and he wanted us to know he would see everybody's. The optional part was whether we would share our profile with all the other members of the crew. He recommended that we do this and have a group discussion around who are we, what factors are making us tick. If strain goes up, pressure goes up, or anxiety goes up, what do we need to understand about each other so that we will have a greater likelihood of performing just as effectively in an anxious or stressful circumstance as we can when things are easygoing? Because everyone has got sort of a home base or default response pattern that they tend to move back to when things get strained. When things are not strained, you've got some more flexibility and more latitude in your ways of interacting with people. That's just normal human nature. So we did that.

It was very illuminating. I think I'd seen the early psych profile that they do on all of us somewhere back years before that. It was interesting to see a new snapshot and look across the whole group. The guy who did that with us had some stats on the kinds of personality modes. His model has, I think, six different personality modes. It was Myers-Briggs-like, but it wasn't that model. The normal distribution of those modes across the population, and the way the Astronaut Office is constructed. My recollection is the two very mission- or purpose- or goal-oriented types out of the six constitute typically on the order maybe 15 percent of the general population, but those two types constitute 95 or 98 percent of the astronaut population.

Whereas more dreamer or salesman type folks are very underrepresented in the astronaut population. Not an altogether unexpected thing, but I didn't know that mixture of distributions. It was interesting. I found it helpful. I think it did open up a couple different avenues of conversation across the crew. Byron Lichtenberg had been a candidate for the mission specialist selection back with our group and had not made it into the class. He ended up with the Spacelab 1 team and had flown as a payload specialist on Spacelab 1.

There'd been some bit of tension around, "Scientists are flying. We gave up our careers and came over to become astronauts, and then these guys are flying before we are." There was a little bit of that in the astronaut/ESA [European Space Agency]/Spacelab world in the early '80s, I hadn't known Byron well. I just only had sort of an impression of him out of Spacelab 1. I think he and I, in particular, got an interesting different angle each on the other, and went off and had a beer and talked about it some. We live in different worlds and haven't worked together since the flight, but we became much better able to support each other, understand each other, and really work together as colleagues driving both shifts because of the exercise that we did there, than if we had just gone in with whatever stereotype or bits of impressions we had of each other from back in the early '80s. So it was really helpful.

ROSS-NAZZAL: Any other thoughts about the mission itself? I know you worked on SAREX [Shuttle Amateur Radio Experiment].

SULLIVAN: Yes. The ham radio stuff was very fun. We all got into that. We used Dave's call sign. Although several of us got a no-key amateur license just as part of making sure we trained

well. I wasn't quite sure what to expect of that as we were training, but once we got up there, it was quite fun.

Some of my more amusing recollections come out of that. I think Dave and I in particular got into this. Dave was the key SAREX guy on the Red shift and me on the Blue shift. I figured out pretty quickly that it wasn't going to be hard to talk to people on every continent. Ham radio guys have all sorts of little milestones that they notch their belts with, and one of them is, "Worked all seven continents." So sitting in your backyard in Columbus, through the magic of ham radio antennas, you talk to someone on every one of the seven continents. Well, there's not a lot of people in Antarctica to talk to. For a lot of reasons getting Antarctica is not a trivial thing to do, but we had some passes, especially on the Red shift, where our high latitude southern passes were near the Antarctic Peninsula, where places like the US Palmer Station is. So it was becoming pretty fun to look out the window. I remember one pass where I could see all of New Zealand at night.

As you go by, you're hearing call signs from different people. It's very quick. It's not really conversation. So many people are eager for the opportunity to say they reached the Shuttle that if you threw out your call sign and the code word that says, "Anybody out there," you would just have a flood of voices coming back. You'd pick a call sign and say, "Whiskey Charlie Alpha Roger," and they could now write a little card that says, "I got a two-way exchange. That counts." You're just traffic-copping a lot of these things, but it was quite fun. I particularly liked at night when you'd see a whole continent lit by light and be talking to people. Just imagine, it's after dinner. They're spending some time on the radio. They know you're overhead. You're probably a satellite in their sky. They're really keen to be talking to you.

I worked some passes across Australia one time where we had three successive passes, each one several hundred miles further west because the Earth rotates underneath you. One was offshore, one was probably right about over the Sydney coastal area, and then one was inshore from that. On the third pass, I picked up a call sign and acknowledged it. A man's voice came up quickly pleading, "Could I talk a little more?" He'd been working all three passes, an hour and a half between them. It was now pretty late on the ground in Australia. He had his six- or seven-year-old daughter there who he really had wanted to connect so she could say hello to someone on the Shuttle. So I told all other frequencies stand by and spent a couple minutes talking with his little girl. I thought it was just kind of neat.

Dave woke me up one night. He finally reached Antarctica and connected with someone at Palmer Station. He'd already been telling me about how he was going to try to do that, because it's only a tiny window of time. "If you catch them on one night, ask them if they'll commit to man the radio the next night. Wake me up for that one, so I can talk to Antarctica and chalk that one off." So the second night he gets me up. It's all set, and I make the contact with Antarctica.

Duffy has been a bit above all of this for a while. He had his license, but he's busy. He's got lots of things to do. So Dave and I are down after that evening when I connected with Antarctica, and we're both celebrating at the shift handover that we've now both talked to all seven continents, that's very cool. Suddenly I see Duffy counting on his fingers and racking up how many he's gotten, and he realizes—I think he needed Asia, and then he'd get Antarctica the next night with David. So he needs Asia. We had some night pass coming up right along just offshore parallel to the islands of Japan. Duffy has got this figured out in his head.

I remember he takes the antenna, stuffs it in the window, picks up the handset, throws out the call sign to Japan. There's rabid ham fans in Japan. He throws the call sign out. Honest to goodness, it sounded like 100,000 voices came back. He grabbed one call sign, said, "Roger, got you," turned off the radio and pulled out the antenna. I said, "Duffy, you are cruel. There are 99,999 really disappointed people on the ground there."

(Break in audio)

ROSS-NAZZAL: You were talking about Brian Duffy and shutting off his radio.

SULLIVAN: Yes, absolutely cruel. The other fun thing I remember—ham radiowise—is that when we landed, in all of the postflight milling about, waiting for people to regroup at the welcome back event, I had a second to chat with Jan [Janet M.] Duffy. Duffy's son Shaun—who would have been something around seven, fairly young at the time of this flight—while Daddy was in orbit, had gone and gotten his ham license. Jan was looking forward to having Brian discover when they got back to Houston was Shaun was now a ham radio operator. I just thought that was going to be a neat little bit of homecoming news.

ROSS-NAZZAL: Yes, very cool. Anything else stand out about that mission in terms of experiments? I've got some other questions, but I wasn't sure if you wanted to talk about them; no one really has shared those sort of details with us about that flight.

SULLIVAN: The rest of the experiment ops were pretty benign, pretty vanilla. It was notable to have an in-flight press conference with the king of Belgium, because Dirk, the first Belgian citizen to fly, was aboard. We will soon have the first European commander of the Space Station [Frank De Winne], who will also be Belgian. Set up the cameras and all that preparation, and all seven of us mustered up with Dirk right at the middle. It was going to be Dirk and Charlie, of course—the commander and the guest of honor, with the rest of us clearly and properly as window dressing.

Dirk, bless his heart—as we were preparing for it, he said, “Well, no. We’re going to want the microphone here so I can pass it to you for other questions.” We said, “No, Dirk, this is not going to be necessary. The microphone is going to start here with Charlie, and then it’s going to go to you.” “No, no, no, but he will want to speak—.” “No, trust me, your king is not going to need to speak to any of us. We are window dressing. This is just fine, don’t worry about it.” So that was fun.

ROSS-NAZZAL: Any challenges on that flight other than the fuse?

SULLIVAN: Other than the fuse blowing, no. No real significant anomalies. Experiment ops all went standardly pretty smooth. No spacewalk issues of course. We were doing some filming for one of the first Johnson Space Center efforts at educational videos. That did generate one of the funnier moments. I’m a pretty good photographer and can be fairly finicky about composition and lighting. I’m sure my crewmates could say I would be outrageously, obnoxiously, and foolishly finicky about some of those things. Duffy is trying to film something on the middeck with the camera way over by the WCS [Waste Collection System]. I’m two thirds of the way

towards the starboard side up by the front. The idea is I'll be floating free, not attached to anything, with an inflated Earth globe spinning next to me. That'll be the fun visual cue that "No, no, really, we filmed this in orbit."

We're trying to get the angle right and the lighting right, because you almost couldn't get far enough away with the camera to get the shot we want. We had these funky little cage-protected lights that would mount on top of the Arriflex camera to brighten a scene. They had cages around them because they would get so hot. We're back and forth, we're tweaking, I'm being finicky and obnoxious. Duffy is probably just about ready to kill me. Finally he says, "We're going to do this."

So I go over, get in position. He starts the camera going. He goes to flip the big on-off toggle switch on this light. The light was never really quite designed to mount to an Arriflex camera, and so everybody had been cobbling it together with tape and other things. Duffy gets the camera going. His jaw muscles were just about giving up. He's got his teeth clenched so tight trying not to snap at me. He flips the switch on the light. The switch is so stiff that in flipping it he undoes all of the tape and the light just launches from the camera and goes spiraling up towards the ceiling. This look of combined astonishment, rage, and utter frustration flashes across his face. I completely lost it and just let go of the bulkhead and just started cracking up. The scene is this flashing strobe as the light goes by and me floating in a ball of laughter drifting off. We didn't get that scene. We stopped right there.

ROSS-NAZZAL: Needed a moment, huh?



SULLIVAN: Yes, we needed one. Yes, and I also remember Dave and Duffy doing a golf tournament. Balling up a sock, and tying it up with gray tape—they're both avid golfers—taking the inspection mirror out, and Dave did a little chip shot across from one side of the middeck to the other. Then he tried to get clever and calculate how many seconds. They made the cup. They took a roll of gray tape and put it on the galley wall with a pencil sticking out of it, as if that was the hole and the greens flag. So just monkeying around and having a bit of a good time.

ROSS-NAZZAL: Charlie told us that he agreed to have the crew taken off on gurneys. Do you recall this? Were you one of the participants?

SULLIVAN: I wasn't taken off on a gurney.

ROSS-NAZZAL: No? Okay.

SULLIVAN: No. Walked into the crew transfer van and sat on the brown Barcaloungers.

ROSS-NAZZAL: He had mentioned that there was some study. Somebody wanted to study the impact of zero G on the human body, and that it would be better if people came off in gurneys rather than experiencing too much gravity.

SULLIVAN: That did not happen. One of the experiments that I participated in was basically a kinematics, body mechanics. Preflight they get you to a little studio, put on gym clothes, put little luminescent dots, IR [Infrared] dots, on different key joints, so they could film you in low

light with IR and do stick mapping of your body mechanics as you walked, trotted, and ran, running through different speeds on a treadmill. They'd get a couple baseline data takes before flight. That was one of the groups. There's always several that would like to catch you ASAP [As Soon As Possible] after landing without much gravity influence yet evident and see if they can map the readaptation back to one G. That was one of the groups that was eager to get you back into the lab as quickly as possible after touchdown so they could see if there was any residual change in your gait or behavior. We did that. I got there within forty-five minutes or an hour after landing. Minor but not very substantial differences from the preflight routine.

We didn't get off on gurneys. That was the only time I got off on a CTV [Crew Transport Vehicle], the Dulles Airport transporter vehicles that NASA got several of so that you could bring it out on the runway, raise the cab to the height of the hatch so it's a level, no one has to go up and down stairs, which is both a balance concern and a trip and fall concern. From the medical guys that want experimental data, the mechanics of going down a stair are certainly going to be probably inducing more gravity effects faster than just walking on a level surface. The CTV had, like I said, the Barcalounger. Same kind of recliners that you would have at Kennedy [Space Center, Florida] before you got on board that can accommodate you in a pressure suit and can lean back. So if someone is having any orthostatic issues, or if they're just tired, or if you want to minimize the readjustment, you can put them close to horizontal in the loungers and just drive them off the runway right to the O&C [Operations and Checkout] building, right to the flight clinic, or right to wherever your postflight biomedical facility is, if there's a special area set up, and go at it.

ROSS-NAZZAL: The only other question I had about this flight is did you go on the PR flight to Belgium.

SULLIVAN: I did not go on the PR trip to Belgium. I was either about to go into confirmation hearings or just confirmed at NOAA [National Oceanic and Atmospheric Administration], when that came along. I ended up having to stay behind.

ROSS-NAZZAL: When you were working this flight, were you considering leaving NASA at that point?

SULLIVAN: Yes. A friend of mine had been serving as NOAA chief scientist from something like 1989 or '90. Around Christmastime of 1991 or early part of '92, she got in touch with me and said that a variety of family factors—aging mother and things like that—she had realized she needed to step down from the chief scientist post. She wanted to put my name in to the White House or in to the secretary of commerce as a candidate replacement. Was I interested? Would I let my name go forward? If I was, could I get up to Washington in the next three to six weeks for a courtesy visit with the under secretary of commerce that runs NOAA.

I thought about that for a while. The turnaround between 31 and 45 had been reasonably tight, '90 and '92, and I was happy for that. It had been a long gap from the first to the second flight, so I was pleased to have a quick turn. I'd realized in the run-up to 45 that I was feeling I would really be ready for a bit of a downtime, some kind of shift, a little bit of certainly a timeout in terms of not a quick turnaround to another flight. Coming up on fifteen years in the program I was probably at a point where I really ought to do a personal review, taking stock, and

consider. Either reconfirm that yes and yea verily this is still exactly where I want to be, and the outlook of things that I can see to be a part of, and opportunities in this arena are just what I want for a goodly 'nother five to ten years as far as I can tell. Or, are interests and desires for personal growth and professional development, are they shifting at all and beginning to argue for some readjustment.

I had found for a couple years, I guess, that I was enjoying more and more the chances I had to really get more deeply into educational program design, museum advisory work, all done on a volunteer basis. I'd really loved the creativity and the challenge of designing the Challenger Center Program for June Scobee and getting that launched for her. That had really been fun. As I followed the general progress of things in oceanography, satellite remote sensing, and environmental science, I was finding that was claiming more and more active interest compared to my earlier years in the program.

Those two things alone had me questioning, "Do I want to see if there's a way to craft a different mixture of those things into being an astronaut, or are they early signs that there's another direction that's worth considering for the next phase of my career?" That was as far as I'd gotten. Good moment to take a bit of a timeout and do a rethink and consider where you are and what the next career phases are that are important to you.

Then this offer came up, and, NOAA, there's not another agency that captures so many of the things that I've always been interested in. It's geography, information systems, and geographic mapping. It's coastal survey, it's ships, it's spacecraft, it's airplanes, it's weather, it's everything. Just on first principles, well, the first answer ought to be certainly I'd like to have that next conversation. The secretary is going to have a slate. It's not a foregone conclusion. I talked with Charlie about it. Told him it was at least intriguing enough that I'd like to work our

schedule so that I could pop up to Washington and have a courtesy meeting with these guys and see, just take at least that step. He worked with me to arrange that. That would have been probably sometime in early February. Just went up and came back down.

Then put my head back into flight and went off and flew. The guy who was heading NOAA at the time was John [A.] Knauss from Rhode Island. He actually reached me by phone in the crew quarters on landing day. My thinking in the weeks after meeting with him, as we ran forward, headed in the direction that this would be a really interesting thing to do. It's a presidential appointment. It's not a career civil service slot. It left lots of opportunities to consider crafting it as a leave of absence from the agency, not necessarily a one-way street. It could be a really pretty interesting thing to do, to get regrounded in the sciences, get a closer look at the industry and academic side of things, and just for general education and general information. Maybe that would add up, if I did it, to a decision that it was time to move in other fundamental career directions. Maybe it would just be a breather and refreshing pause, and I'd end up back in NASA or staying in NOAA. Couldn't foresee all of that, but it had become more and more interesting to have a two-to-four-year stint in something like that.

John reached me, actually, in the crew quarters before we got on the planes and came back to Houston. I've always wondered if he waited until we landed to be sure I was going to get back. Said he'd made his decision, and I was indeed the person whose name he would like to send forward to the White House, if I would confirm that I was still interested and give him some sense of when I might be able to get up to Washington and take some next steps. So off we went.

ROSS-NAZZAL: When did you officially accept that position?

SULLIVAN: I decided to sell my house, and move to Washington, and just take it as a blank slate whether I would end up doing a long time in Washington or come back to Houston. Just free up everything and be open to whatever came next. I packed up and moved to Washington in July of '92. My nomination had already gone over to the Senate. It went over to the Senate in April. I'd asked NASA to detail me to NOAA so I still had my career status and was a NASA person on loan to NOAA for that window of time between nomination and confirmation.

Well, it was a Bush 41 [George H.W. Bush] nomination, so of course that went OBE in November of '92 when he lost the election to President [William J.] Clinton. I, in the meanwhile, had decided this really did look like an interesting thing I'd like to do so I set about trying to figure out how to make the case that I should be the new group's nominee. I'm about as apolitical as you can get, thanks in part to the Hatch Act. I'm a competent safe neutral choice for any administration. I can serve either administration, and I would like to serve as the chief scientist. I managed to figure that out and make that case, and so got renominated by the Clinton team in early '93 and finally confirmed by the Senate in like March of '93.

ROSS-NAZZAL: Did you have to testify?

SULLIVAN: Yes.

ROSS-NAZZAL: How did that go?

SULLIVAN: That was pretty funny. The three presidential nominees who were tapped to head NOAA all testified at the same hearing. So there was the under secretary for oceans and atmosphere, who's the administrator of NOAA; there's the assistant secretary, who's also the NOAA deputy. Traditionally that's the guy that handles all the coastal zone management and fisheries regulation issues. Then there's the chief scientist.

We did all the briefing books, murder boards, and things that you normally do. We had one session in particular where Jim [D. James] Baker, who was going to be the head of NOAA, wanted to get more intense on, "Now what are the things they're really going to roll in and chew on us about?" I said, "Jim, these are great. We'll do all the murder boards, but here's how it's going to go. You, they're going to roll in on and chew on, because they need to make the point, at least the gesture, to you, about the executive-legislative branch tension, the checks and balances, and plant the message with you that you dare not think that you unilaterally control this agency." They have strong say over it, and their constituencies matter. "Doug they're going to wire-brush because he's going to be the guy working fisheries and coastal zone stuff that gets directly to resource usage, coastal development, and fisheries income. They're going to want to make doggone sure that he knows that their voices and concerns matter and is suitably respectful to them. Then they're going to turn to me, and you know what, people don't jump astronauts." So there's a couple things. "A) I'm an astronaut. I haven't done anything political to be attacked for. Couldn't have. I'd be in jail if I'd done it. Frankly, no one quite knows on the Hill what the chief scientist does." Baker and I had been talking about a much more significant portfolio for the chief scientist than some of the preceding administrators had wished to have happen, so that was intriguing.

Sure enough, we sat there and there was Q&A [Questions and Answers] and a little bit of posturing, wire-brushing for Dr. Baker; and then there was testimony, Q&A, and a bit of wire-brushing for would-be Assistant Secretary Hall; and then I read my statement. I'm blank on who the committee members were, but the first guy rolls in with a mini-speech of, "The nation is just so lucky that people like you will serve." It was just applause. Another guy rolls in with a question about the Law of the Sea Treaty, and should it be resurrected, should the Senate take it back up again, something like that. He had asked Doug about it. He was following up with me.

I said, "Senator, frankly, the last time I paid close attention to law of sea deliberations was when I was in graduate school as an oceanographer. I've, as you know, been busy with other things since then so I'm really not able to give you a good answer to that question." I was about to say, "But I'd be happy to look into it and get back to you." Another guy down the row on the bench slaps the table and says, "she's not afraid to say when she doesn't know something. I like that honesty. We could use some of that." End of hearing. That was the end of my hearing. End. Done. "Thank you for serving, Dr. Sullivan." "Yes, sir, happy to do so." That was it.

ROSS-NAZZAL: You were sworn in then?

SULLIVAN: Soon after, by the secretary of commerce.

ROSS-NAZZAL: Who was the secretary of commerce at that point?



SULLIVAN: Ron [Ronald H.] Brown, who later died in a plane crash in Yugoslavia a couple years later.

ROSS-NAZZAL: What were your duties as chief scientist? You mentioned that there might be this expanded role.

SULLIVAN: The NOAA chief scientist job actually has line authority over the agency in the absence of the head of the agency. The structure of the agency is: the administrator is first, the assistant secretary is the deputy, and the third ranking political appointee is the chief scientist. Then there's a person, usually a career or political civil service person, called the deputy under secretary, who's kind of the chief operating officer.

So NOAA's chief scientist is a post that has line authority, but its mandate is carved out in the statute to oversee the laboratories, research, technology, and development programs that support the agency's mission work. There's a slew of labs in the atmospheric sciences, a number of oceanography laboratories, physical and coastal oceanography labs, a slew of fisheries laboratories, and a variety of university cooperative research programs. So what is that whole mix? How is it structured? How is it operating? What are emerging needs? What are the coming scientific issues? Just general oversight of those things. You've got line managers running the day-to-day aspects of any of those, but from a strategy and policy point of view, the idea was that the chief scientist could be the one person on the senior leadership team who, by statute and by internal decision, is not so tightly coupled and driven by the day-to-day political issues or contract and budget administration issues. The scientist can help the administrator have that longer more strategic view over how the agency is positioned in science and technology.

We, the administrator and I, had talked about the fact that no one's ever done a comprehensive review of NOAA's labs to really take a look at what is the portfolio, what's really there in some depth. That could be a good thing to do. There were a number of shifts or potential shifts in university relationships that were burbling around. How should we position for those? There were a number of things like that. NOAA is the US signatory for a small array of bilateral scientific agreements in oceanic and atmospheric sciences. The chief scientist could take the ball on those. So it was looking pretty fun.

I did indeed serve as acting administrator of the agency for about a forty-eight-hour period. It was an amusing forty-eight-hour period. NOAA specifies contracts and funds the national weather satellites. NASA acts as a delivery agent, integration agent, and launch agent. People get very confused about whether they're NASA weather satellites or NOAA weather satellites. They're NOAA weather satellites. It's on our budget authority. One of them had just gone lost on its way to orbit, hours after I took over. I got the fun of having the, "Excuse me, we've lost a satellite," phone call, of starting to stand up the incident team, and having to do a little bit of jousting with my former colleagues at NASA. "Excuse me, this was your launch responsibility and your launch vehicle. I'm chairing the anomaly team, not you. This is our incident team, because it's our money, and it was our satellite that we now don't know where it is."

ROSS-NAZZAL: What happened to it? Did you eventually determine?

SULLIVAN: It was just a launch bus malfunction. It was fun, fun times.

ROSS-NAZZAL: Did you formulate any sort of new policy or create any sort of new programs while you were in this position?

SULLIVAN: We're all watching the confirmation process. With a relatively new administration, the rate at which nominations and confirmations percolate through all the different positions can be slow. I actually was confirmed fairly early relative to the Department of Commerce. Another branch of Commerce, the Technology Administration, had been asked by the White House to take a fresh look at environmental technology export policy, cleanup, remediation kind of technologies. The under secretary for technology was already confirmed, but no one else with real technical background was confirmed in that branch or frankly anywhere else in Commerce.

My first big assignment, once the confirmation came through, was to head up the interagency group that was going to review, for the White House, United States environmental technology export policy, which we did. We did hearings. We did all the interagency meetings, all the data gathering. Generated a report, recommendations, and the draft presidential decision directive.

The net result of that was a presidential decision directive that was announced by Secretary Brown and EPA [Environmental Protection Agency] Administrator [Carol M.] Browner in a big ceremony at the Department of Commerce. Within about five months of getting aboard, I'd written new US policy. We had a renegotiation somewhere about within that first twelve to eighteen months. It was a US-Russian bilateral agreement on ocean sciences and exploration. That was all being worked through the policy and renegotiation process rounds and coordinating rounds. I monitored that, and took the last stages of it, and actually was the US

signatory at a meeting in Seattle [Washington]. Led the lab review. That was a big long undertaking that we completed in late '95 early '96. Yes, so there were a number of things.

ROSS-NAZZAL: What about global climate change? Was that a big issue while you were working there?

SULLIVAN: Yes, NOAA was a pretty key player in the US Global Climate Change Research Program [USGCRP]. That was then steered out of FCCSET (the Federal Coordinating Council for Science, Engineering, and Technology). That's a White House body to try to make sure that there's some integration and coherence across all the activities of all the different agencies. Baker, I, and others followed the FCCSET and the USGCRP pretty closely. We had a guy named Mike. Losing another name. I can see his face. I'm losing his last name, but there was a NOAA senior scientist who'd been in on USGCRP from the beginning, and in particular our oceans and atmosphere research arm administrator, the equivalent of the NASA AA [Associate Administrator], who kept close day-to-day charge on that. We were informed and involved, but it had really not reached the policy point yet that it's gotten to now.

This was the early days of the IPCC [Intergovernmental Panel on Climate Change] reports so we had a lot of NOAA folks from our labs on different IPCC panels. In fact, Susan Solomon, from one of the NOAA labs out in Boulder [Colorado], led the key working groups on IPCC IV, which is the effort that recently received the Nobel Prize.

ROSS-NAZZAL: Oh, very cool.

SULLIVAN: Yes, it's a good group. What else did we do? Oh, let's see. We signed the first policy decision and funding steps towards what is now a new US scientific station at the South Pole. That started on our watch. We were guiding those reports, another Norm [Norman R.] Augustine effort. Weighing and making the recommendations to OMB [Office of Management and Budget] and others. Do we try to renovate the current station, or do we shift and make a new station? A couple new research vessel commitments that got started that have since been launched and commissioned that are in the NOAA fleet, even before I was confirmed actually.

In August '92, Hurricane Andrew came slamming ashore. NOAA had long had on the shelf an emergency backup plan for the National Hurricane Center, which was located right in the bull's-eye of what was projected for landfall for Andrew, but they'd never actually activated or really even rehearsed it. One of the things I'd done at NASA, like '88, '89, I'd been part of the group working in and with mission control to develop the emergency mission control center plan [EMCC]. In fact, we'd decided to activate it in backup mode, in shadow mode, in a pretty full-up exercise in association with a flight late in '88, I think. I went out to White Sands [Test Facility, Las Cruces, New Mexico]. I was driving to California for Christmas holiday. Met everybody else that scrambled out there with the aircraft activation plan we'd written and ran a dry run on our whole EMCC plan. This was back in the days when you couldn't guarantee continuity of communications to and from an airborne airplane with the Shuttle. You can do that now. Cell phones almost didn't exist then. It was how do you deal with the coms gap, but it was very relevant experience to walk in the door at NOAA with a hurricane about to hit the National Hurricane Center.

The first thing John Knauss asked me to do was get that backup plan off the shelf and review it and get over with the NOAA guys in Maryland, which is where that the backup would

be, and be sure we were ready to step in for the National Hurricane Center if the center got knocked out. We did that whole thing. Then I ended up on the ground in South Dade [Florida], about ten days after Andrew went through, with our disaster response teams, looking after the Commerce Department personnel in the area. We had about seventy-five people in the whole Miami area, in our fisheries labs, the hurricane lab, and the hurricane center. Most everybody had lost their homes. Any institutional capacity to deliver payroll was pretty well knocked out. It was an incredible mess. I wasn't even confirmed yet, but I went down there and checked on our folks, helped get a disaster survey team going, and helped set up the site visits for the secretary of commerce and the head of FEMA [Federal Emergency Management Agency].

Let me clarify. I made no official decisions. We took our then assistant secretary down with me, so we had someone duly and properly authorized to make decisions and act on the part of the agency. I didn't do any of that, but I was certainly able to help, advise, and guide some things informally.

ROSS-NAZZAL: Was Al [Albert A.] Gore [Jr.] a player at all when you were working at NOAA? Did you do any work with him?

SULLIVAN: I did very little directly with the vice president. Towards the latter time of my tenure, he was getting started on Project GLOBE [Global Learning and Observations to Benefit the Environment], this grassroots program for kids across the world to make environmental observations and take advantage of the still emerging Internet capacity. This is 1994 and 1995, so you have to remember the Internet experience then wasn't anything like it is today. The notion back then that kids in any country across the globe, from the First World to the Third

World, could make some observations and have some computer or handheld interface that would let them convey those observations to some global repository where they could feel they were a part of contributing to a global understanding was unthinkable. That was a fair bit of technological stretch for more remote parts of the world. I worked more with his staff and the group that he started building around that project than with him directly on that project. I was a mere subcabinet appointee.

ROSS-NAZZAL: Why did you decide to leave the government in '96 and move to Ohio?

SULLIVAN: I stole a device from a friend who I'd met in Washington to help shape thinking about the future. I guess what was happening was I was really having fun at NOAA. I was getting a fresh look at the corporate sector and another look at academia. But I really wanted a chance to shape, design, and lead something. I'd come to two conclusions about opportunities to do that within NASA or within the government in general.

From what I had seen within NASA at the time, even very capable women who I thought very highly of and respected quite a lot seemed almost never to get above deputy. They could do incredible work, save programs, you name it, and they'd be offered a lateral move to be somebody else's deputy. There'd been one female Center Director for a brief tenure [JSC Center Director Carolyn L. Huntoon]. I looked at that and said, "It looks to me like this is not yet an avenue where there's high probability of leading a Center or leading a major program. It doesn't look very likely."

Secondly, when I really thought more carefully about the leadership challenges I'm really interested in taking on and developing in myself, I realized that you don't have the same kind of

latitude in most government programs that you do if you're actually creating a product, running a business, conceiving of a program, and having to conceive, design, formulate, organize, deliver, muster the resources, the whole thing. I found, bigger challenge though that is and more daunting in some ways, I actually wanted to have a shot at getting my arms around the whole of something like that.

Then just considering my age at the time and the career point I'm at, because I was just forty, forty-one, something like that, if you want to add a really different next chapter in your professional life, the early forties is a good time to do that. You've got good running room ahead of you. If you decide to stay another five to ten years in government or back at NASA, it's not that that's closed off by any means, but it's just different. You're at a different point in life. It seemed like the right, still-fertile, vibrant point in time to launch. If you're going to launch a whole new chapter, jump in now at this still-fresh vibrant phase and go for it and see what it becomes.

That was the first conclusion. Then my consideration was, well, so where does that mean I want to head to? I realized, well, the astronaut experience and the presidential Washington experience, if there was ever a pathway for someone trained originally as an academic to end up working in industry, this would be the juncture to look at that opportunity. I don't actually know anything about living and working in the corporate environment. I'd never done it. So how would I get some information? That's where this approach that a friend had used was informative. It boils down to: look around your circle of colleagues and acquaintances. Find people who are at a position of accomplishment and seniority that gives them a broad field of view or really insightful perspective across a sector, a field, or a domain of work, and who know you well enough that they have a good sense of your strengths and weaknesses, and also will be



candid with you about their assessment. Ask them if you can take them to lunch and understand how their world works. It's not asking for a job.

I made a list of people I knew, mainly in the corporate world, because I figured that's the next plausible choice. Academia or the museum world—both had some interest, especially the museum world—could more logically come after a corporate stint than if I went back to one of those fields and then tried to come back into the corporate world.

I made a list of people I knew who were successful and well positioned in different companies. I actually started this relatively early after I was confirmed, because it was not about looking for a job. It was about adding food to my thought banks so that I had more to work with as I evaluated, "What am I really interested in? What really matters to me?" I bought about a dozen people lunches. "How does this world work? What are the greatest things? What are the best parts of it? What are the ugly parts of it? What are the huge challenges? What drew you into it? What keeps you in it?" If at the end of this term, two or three years from now, I were going to parachute into this world, "What's your sense of what the emerging really interesting challenges and opportunities would be? That if I decided over time that I wanted to parachute in here, those would be cool things to aim to be involved in." Preview of coming attractions. What do you think that's going to be?

Nice lunches. Would make some notes afterwards. Then let about six or eight, nine months go by just thinking about it. Eventually went back to a couple three of them and said, "I think I am going to leave government, and this might be the direction I'll go. Who can I have a next conversation with?" That fairly quickly, quite gratifyingly led to some nice, notable, make your banker very happy type of corporate offers. I kept finding that I could analyze the daylight out of those offers, but there was just nothing in my tummy that convinced me I would leap out

of bed as eager for the next day as I had up until that point, from—shucks, high school onwards. I'm just used to that. "Oh, a new day, good." This was going to be, "Oh, God, another day." I said to myself, "This is probably a sign here that something isn't jibing here."

Right around that time, a headhunter approached me, in part about corporate board opportunities, but also it was probably a little bit of a bait and switch. We've remained good friends since. She was leading the search for the new CEO [Chief Executive Officer] at COSI [Center of Science and Industry, Columbus, Ohio]. I knew of COSI from my other museum work. I had been aware through the grapevine that the CEO slot was open. It was just out of my field of view enough I hadn't ever really given serious thought to the position. I didn't know anything about Columbus or Ohio, so it was just not on my radar screen. We met, and we talked about it. COSI was at a very interesting point in its evolution.

They needed someone to run the museum, plus they were building a new building. There was going to be a complete move, and the transformation of everything about the organization that goes with a move of that scale. They clearly had not yet done most of the detailed work and creative work around the education program. "What should the new suite of programs be? How do you transform the ones you're going to keep? What new ones do you need? What are the new exhibits?" None of that had really been done.

So I agreed to go out and have at least a first meeting with them. I did that, I guess, in about October of '95.

Meanwhile, during the latter part of '95 I had a very eager, almost frantically insistent senior corporate guy wanting a quick answer. "I need to know. I've got to have you here." So I have this still rather vague prospect with a group of people, in this odd place out in Ohio, who are probably still looking at the state of four to six candidates, and I don't know if I would even

be their final pick. But I was ducking the corporate guy's phone calls, I realized. So all that was swirling around during the last couple months of 1995.

It really was an interesting contrast. The corporate opportunity was a pretty typical next step for an astronaut to take, but the COSI prospect was one that even I had not been thinking of at the start. I could imagine some of the reactions from my family and friends. "You're doing what? You're moving where?" As opposed to, "Oh, VP technology for the umpty-fratz corporation, wow!" That probably would have read as a better press release, and undoubtedly would have made more sense to my banker. Was a lot more comfortable probably. Challenging but in some ways comfortable to go the corporate route.

But the COSI gig had good people. It was a big challenge. It was community and a board. The interview visits let me see enough people to know that this was a community and board that does not micromanage their nonprofit CEO. Your authority will be real. Your responsibility will be real. Your latitude to shape the organizational culture, process, performance targets, strategy: it's all genuine. Make or break, it's your ball. As we sorted out the details on this end, we basically pulled several jobs together. When I came out here, I was charged and had agreed both to run the current museum and to serve as CEO of a separate entity; set up a separate entity to raise the funds and oversee the design and construction of the building and the exhibits and the procurement of all the systems. I did both of those jobs. Bid, built, equipped, and opened a \$125 million new building a couple three years later, on time, under budget. It's today humming along as the named number one science center in the country by a national magazine. So good stuff.

ROSS-NAZZAL: How did you get to Ohio State University [Columbus, Ohio], then, from there?

SULLIVAN: I ran COSI from '96 to essentially 2006, just a couple months shy of ten full years. We built the building. We opened. We ran through all the shakedowns and challenges of getting everything in order. Your first draft operating budget is never really fully correct to how the system actually works. It takes a couple years to shake that out, get all the guest service operations smoothed back down and rebuild cash balances. Draw your donors back in. Rebuild the membership.

We really had all that work done, with all the unit vectors lined up in the right direction. We did a final restructuring of the budget and the operating structure to be able to use this gigantic facility as a multipurpose platform. So it hosts today the science museum, the public radio and TV station from the university, and some university laboratories and a family research center. It's a community platform, if you will, for public outreach, especially science and technology-oriented public outreach, and education. It's got a much more multifaceted character than COSI had before. That was kind of all done.

We were at a plateau where the next step really is to restart a new conversation with the community about now, "How are we sustaining this and what direction are we taking it in." As I looked, I could see that coming, and forecast the main blocks of activities for about another five or ten years. I realized one day that felt an awful lot like a replay of the planning, strategy, and building of relationships work of the preceding ten years, without the extra gratifying challenge of the same amount of design work and creative work that we got to do when we were conceiving of the new exhibits and programs. I just realized—it just struck me very clearly one day. "I've done my phase. Time for me to shift gears." The board and I had talked the whole time I'd been there about trying to emulate a model that our zoo uses and uses to great effect.

There's a symbolic leader of the zoo named Jack Hanna who over twenty-some years has become quite a media personality. He really is the popular public face of the zoo. Then there's a CEO who runs the zoo day to day and is comparatively less known in the public sphere. We had talked frequently in the ten years that I was running things that, while it was good—things were fine, and we're performing well—my being so close to all the operations and business processes was at the expense of using, in a more highly leveraged way, my national standing or the kind of media profile I could develop.

When I realized I don't particularly want to do the next round of just the same planning as we did in the last ten years, I brought that conversation up again with the board, and we agreed now we were at a point where we could start to discuss how to separate roles so that I could have that broader strategic public persona. We went back and forth about, "What are we going to call it." They call Jack Hanna director emeritus, because he actually was director for ten or fifteen years before shifting to the media role. We settled eventually on the title of science adviser. They were going to go off and search for a new CEO to replace me. We figured when we get that person aboard, then we'll start really crafting the role and finding out what's the interplay of inside and outside roles.

In that period of time, just as the search completed and the new guy came aboard, Ohio State had been given a major gift to start this new Center of Math & Science Education Policy. The full constraint of the gift is contained in the sentence I just said. "Here's X million dollars for a new Center of Math & Science Education Policy." "Well, so what should it do?" "We don't know." "Pre-K-12?" "If you like." "Undergraduate?" "If you think so." So it was very unconstrained. The university president at the time, who I had known since she arrived and whose husband actually way-back-when in an indirect way had reported to me as chief scientist

at NOAA, grabbed me one day. She told me about the gift and how broadly unconstrained it was and said she had decided the best way to figure out what it ought to do would be to get me and let me figure it out. So stand by, I plan to come recruiting you. I expect to have to recruit you hard, but I want you at the university. By the end of 2006 that's what had happened.

ROSS-NAZZAL: So what stage are you at in terms of this new center?

SULLIVAN: Well, I shifted over in late '96, in the middle of writing a book on leadership in education. Not ever really having thought carefully about how do you make an impact on the science education issues of our day from the policy side of the equation. My modus operandi before that had been working from the platform of a science museum. I can develop exhibits, field trips, overnights, teacher support programs, a lot of things that can take a pretty good shot at improving some outcomes for kids currently in the pipeline, because kids currently in the pipeline are the core of our audience. We can engage with them, and we can do something. We can give them some enrichment. We can give them some motivation. We can improve their teachers' comfort, fluency, and content knowledge. That was one approach.

Now, if you're not going to design and operate programs, but you're still trying to in a sense get to the same objectives, what are the levers? What are the tools? What are the avenues that you can have an impact on? I'd never really given that careful thought. Our agreement for the first year was "I need to finish this book, and I'd like to spend the first year learning, digging into literature, doing basically an environmental scan. Getting myself oriented in this policy landscape and start to answer questions about how do you gain some leverage, and what niches appear to be the ones that are worth going into," with a very creative opportunity here. The way

the gift to the university was structured includes some very patient capital. Some available for speculative wild leaps kind of money that we can play with and try to spark some things. So how do you use that? My take was what kinds of things can you do that would amount to using that in innovative ways, novel ways, not just join the fray and become another lobbyist pacing the halls of the Ohio General Assembly. That idea struck me as a) completely uninteresting at the personal level and b) such a waste of an innovative opportunity that this gift represents.

So 2007 went to the book and the environmental scan. We settled on a couple of lines of initial research that we wanted to start developing in late 2007 and worked on those through '08. We've turned three of those from seeds into seedlings. Now we're in sort of the tend-the-seedlings phase of things and beginning to grow those. Bring in some partners and some external funding. Also still looking for what should the next couple seeds be that we put into place. It's moving along pretty well.

The center lives in the John Glenn School of Public Affairs, which I should clarify means public policy and management; it doesn't mean public affairs in the NASA sense of public affairs. We're not the media shop; we're the public policy and management shop. The Glenn School is developing a real core strength in science and technology policy so I also have that opportunity to contribute there. Over the last year, I worked with a colleague to design, in fact, a graduate level course in science and technology policy, which we've been teaching for the first time this spring quarter. We've got two more class sessions left before it's all done. It's turning out to be very fun. It's such a completely different pace, culture, and structure to things than anywhere I've ever worked before, which is pleasantly relaxing, occasionally mildly disorienting, and frustrating, but interesting to navigate through.

ROSS-NAZZAL: Well, you've had such a varied career. It's very much like the Joe [Joseph P.] Allen career.

SULLIVAN: Yes, the explorer career. As someone once said to me, in anybody else yours would be too wide-ranging a curiosity, but you seem somehow to manage to back it up.

ROSS-NAZZAL: You seem to do everything very well. Are you partnering with your former colleague Sally [K.] Ride in her science camps?

SULLIVAN: I have supported Sally in some of the science festivals and TOYchallenge judgments. Her program design for both of those programs explicitly involves matrixing in scientists, women scientists in particular, from the regions around where the events are held, which is a great thing to do on a couple of counts. It lets the scope of what the company can do be bigger than just the capacity constraints it would have if it was all dependent always on Sally. Also it's actually helping make local school enrichment organizers, local science festival organizers more aware of relationships they can be taking advantage of right nearby them. It increases the chances that, instead of a one-off event when Sally shows up in Dayton [Ohio], that you're helping foster relationships that will continue and keep the Dayton region more active in between grand festivals. It's been fun jumping in on some of those.

[Break in audio]



ROSS-NAZZAL: I thought we'd talk about some of your awards. You've gotten countless awards. I don't know if you want to pick a few. We were talking about your Lone Sailor Award at lunch or if you want to talk about being inducted into the Astronaut Hall of Fame. Girl Scout Award. Those were some of the ones that struck me as maybe more important than the others.

SULLIVAN: Sure. I'm happy to talk about them. Some of them really have meant a lot to me and touched me. Sometimes just in the course of getting acquainted with an organization or all the events around receiving one, I meet people who I find a lot of value in. There's a pleasure, obviously, a bit of satisfaction, sometimes some real interesting learning, and some neat new friends and colleagues out of these things. That's what appeals to me about them.

I guess I would actually reach a little further back than the ones you mentioned for the first one that really fits some of those criteria for me. I hadn't known about the award, a US Jaycees Award. I had, and have still, actually, no idea how its nomination or selection processes go. A person I didn't know at all called me up, said congratulations, and told me I had been named one of the Ten Outstanding Young Americans. That sounded fairly wild. It's an amazing label to apply to anybody. "Will you come to Tulsa [Oklahoma] and accept the award?" Looked it up, and it was an interesting award. You could really resonate with and appreciate the kinds of things it was trying to celebrate and feature in people. Looked at some of the accomplishments and names of folks who'd gotten it before. It seemed legitimate. There didn't seem to be large mismatches between the statements made about the awards and the kind of people listed as honorees. It was not just headline or celebrity, well-known people. It was, in many cases, grassroots unsung activists who were doing great things.

As I looked at all that, I liked that. I liked that it's not just people whose path through life happens to put them on a media radar screen. That's not the only group of people, by any means, that's doing meaningful work, and certainly not the only group that's doing all the important work. I like and really respect award programs that get below that easy, obvious level of titles or press releases and help lift up, propel, or celebrate the kind of works we all need happening around us. So this seemed like one of them.

I was more than a little bit amazed. It was kind of wild. Went up to Tulsa. Turns out a couple who was active in the Jaycees leadership had nominated me. I don't know them at all. This was entirely their doing to decide that I, with the spacewalk and other things, was worthy of acknowledgement. It was a great event. It was a lot of fun. The group of five or six of us that were getting the award that year jelled, bonded, and had a really good time together in the day and a half at Tulsa. Everybody's story was really interesting. The kind of work they had done and the circumstances they were working in just was against much harder odds in many ways than anything I had done.

I don't say that in some cavalier way to minimize my own skills and the work I've put into my career. That's all well and good, but if you've been in abusive families or come up from poverty, and you've oriented and got yourself on a track that you're actually making something happen for others, that's against a lot more daunting set of odds than anything that I had ever faced. Being an astronaut is a big opportunity, a big challenge, a big responsibility, and you've got to hold up your end of the bargain as an important cog in a big team, but you are an element in a team. You're not doing any of this stuff solo. Some of these folks were really pulling notable accomplishments in civic or social advances, really very much on their own.

Once I met them and saw the award—it's this really fabulous piece of sculpture that I still quite like. It's a brushed silver hand from just below the wrist on, reaching up from out of a marble base, and another similar hand just touching the fingertips from above, which captured nicely the values of the award, of one hand helping another hand, lifting, moving people along. That was probably my first experience being given an award or named to an award that I had in no way aimed at, I didn't even know about. You aim at a college degree, you work hard, and you get it. You aim at a PhD, you work hard, and you get it. You aim at a competition to get a position like astronaut. That was my motif. I'm used to setting a target, going, and getting it done, but the fact that suddenly now I've done something where other people are going to reach out and bestow things on me without my consciously having done anything, that was a very different experience than anything I had ever encountered.

It has happened subsequently too, but that was just so novel to me, that someone who never even knew me would do that. That same group put my name forward to the International Jaycees. In 1987 that group named Ten Outstanding Young People of the World, and I was named to that. All of what I just said about how impressed I was with the kinds of challenges that other fellow awardees had overcome, multiplied by a factor of ten. One of the recipients that year of the international award was one of the maybe very first innovators of microcredit in Bangladesh. So here's just the whole scale of the problem he's trying to contribute to, and the character of the lives that he and the people around him were living. That was just mind-boggling, and it was just plain humbling to be on the same stage getting the same award as someone tackling such a fundamentally different huge social challenge.

So those are two good first examples of my first foray into that kind of an award. I just always learn something and get some inspiration from the other people around me on something

like that. On those kind of cases, man, I always accept the award on behalf of all the people I worked with, because I'm fine and I'm proud to be an emblem and an ambassador for the whole group, but it's a national undertaking. I didn't have to invent the undertaking. It's a national commitment, and it's a tremendous team of people. I just have never felt right getting up on a stage for an award like that and pretending it was all me. "Thank you very much. You finally recognized how fabulous I am." It's just not quite how I look at the stuff.

I was commissioned into the Naval Reserve in 1988. It was a direct commission as a lieutenant commander in the Oceanography Reserve Program. I'd gone that way because I just loved the sea services, loved being at sea. I thought two things. I thought at the moment I have the world's absolutely coolest ops job, but that probably won't always be the case. Second, I'd been trying to figure out some way to retain some really active currency, not just reading the scientific literature, with oceanography. The Navy Reserve had organized a program centered on oceanography and meteorology not too many years before I joined the astronaut corps. So those two threads came together, and I thought this could be a really intriguing way. A National Guard or Reserve commitment was a side activity that required some time periodically away from the office that the Astronaut Office understood. They seemed not to quite have the same conceptual framework around research, of taking time to just go back and do some research somewhere. Plus academic oceanographic research is harder to intersect with in terms of ship schedules at sea. It seemed like a practical and intriguing way to stay current with oceanography in a more applied sense.

I got the commission in 1988 and served nearly a full career. Didn't quite get the full twenty years in. I finally resigned my commission, was discharged as a captain in 2006. I never served active duty. This was Secretary John [F.] Lehman's tenure, and the pathway I got in on

was designed to admit scientific specialists at advanced pay grades to the reserves, to augment the Navy's active duty personnel. All was great. In 1996, not even ten years in, I get a call from someone who's representing the Navy Memorial Foundation.

Now, I'd been in DC when they built the Navy Memorial out on Constitution and Pennsylvania Avenue right at the corner near the Canadian embassy. I love the space. The way they've done the layout, the map, the panels, the friezes that commemorate the major naval battles. Have always found the nine-foot-tall statue of the sailor in his pea jacket and his Dixie cup hat with his seabag at his feet—I just have always loved the space. One of my sailors, while I was commanding a unit in Washington in the reserves, he wanted me to do his reenlistment ceremony and wanted to do it at the memorial. It was a place that really meant a lot to me, and I liked to go down and listen to the summer concerts there. So, back to the Memorial Foundation. This guy calls up and starts talking with me about the Lone Sailor Award.

I listened for a couple minutes, and I was 99.999 percent sure—in fact I was completely sure—that the reason he was calling was because he was thinking I might know of some good candidates for the award. I heard him out a bit and started responding in that vein. He stopped me pretty abruptly and said, “No, I don't think you heard me right.” It took him a couple of go-arounds to finally get through my head that, just like the Jaycees ten years before, they actually had already met, thought, nominated, and decided. He was calling to let me know that I was the recipient of this year's Lone Sailor Award, which struck me just as much as the Jaycees call in 1987. I thought, “My goodness. I've got eight years of direct commission Naval Reserve experience. What about women in the Navy Nursing Corps? Surely you haven't honored all of those sorts of people so fully that you've now got room for an eight-year naval reservist who never even served active duty time.”

They had decided, and that was it. I was delighted. Just amazed that any combination of who I was or what I had done was deemed of high enough visibility and value to the Navy. This award, their language says, “A Lone Sailor statue is presented to sea service veterans.” I’m still only eight years into a reserve career so I’m still not even sure I should be entitled to call myself a veteran. “Sea service veteran who has distinguished themselves, drawing upon their sea service experience, to become successful in their careers and lives while exemplifying the core values of honor, courage, and commitment.” I’m pretty good on honor, courage, and commitment. I’m confident of that. All of that just was flabbergasting. Really cool. I liked that a lot because it was in a sense a signal of confirmation by Navy peers—unsought, unsolicited, unlobbied for—that meant a lot to me.

That was to be bestowed at a fancy black-tie dinner, out at the Richard [M.] Nixon Presidential Library in Yorba Linda, California. I went out there in 1996. President Nixon had been given the award posthumously the year before. His brother Donald was going to accept for him at this event. The Naval Heritage Award is another award that this outfit gives, and they were giving the Naval Heritage Award that year to Bob Hope. So that was a very, very fun evening. An interesting setting. The trophy, the memento that awardees get, is about an eighteen-inch-tall miniature variant, but really heavy, of the same Lone Sailor Award, which I always keep fairly prominently around my office, because I just still love to look at it. I love the statue. I have a fun picture—against a solid wall of US flags—of Bob and Dolores Hope flanked on one side by me and on the other side by President Nixon’s brother. That was a pretty fun evening. I cherish that one. I like that one a whole lot.

Halls of fame are interesting. Some of them, not to trivialize any of them, because I can’t think of one where the folks making decisions are really being either crass or trivial about it, but

in some cases there's a mixture of genuinely wanting to honor the person you're inducting and also wanting to burnish the standing of the hall of fame by being able to persuade someone of that caliber to accept the honor. I always look at any award with a bit of that in mind. Honorary degree is another one that's very nice, but sometimes it's very clear that the school is at least as interested in being able to say that you have one of their honorary degrees as any interest in honoring you. You hang around the awards circuits enough, you learn that giving and getting awards serves many, many purposes in a lot of cases. Not just the substantive purpose of truly marking accomplishment. They get a little wild about those things sometimes.

The first hall of fame I was inducted into was the Ohio Women's Hall of Fame. There's pretty solid substantive folks in that. I know enough now about the panel and the process that that's a pretty solidly determined group. I then later was inducted to the Ohio Veterans Hall of Fame, and obviously, given my commitment to service and my delight at being in the Navy, I liked that an awful lot. Fellow astronaut Suni [Sunita L.] Williams was inducted to the Hall of Fame the same year, actually so we did that ceremony together.

Just a couple months ago, I was downtown here in Columbus in our state office building. Another professor and I were going to meet some officials in the state's Department of Development to get some background on a technology development program that we're featuring in the class we're teaching. Since the last time I was in there they'd made a big installation with wall plaques, flags, and service medallions of the members of the Ohio Veterans Hall of Fame, right at a key juncture where all the stairways and escalators converge. Wow, that's a neat layout. I drug him over and said, "See anyone you know?" "Oh, wait! Oh, you are? You were in the Navy? I didn't know."

Then in 2004, I was inducted into the Astronaut Hall of Fame. That's very much a meaningful one. Astronaut is a small club to start with, astronaut, cosmonaut, all labels, all nations. I haven't checked the numbers recently, but it's probably still just under or around 500 human beings ever in the course of time that have had that experience. It's a very tiny club to begin with. The US Astronaut Hall of Fame [Titusville, Florida], it's not just a one for one, if you flew you get in. There's a subset. It's probably running about 10 percent or 15 percent. It is a vote of your peers who were admitted before. The folks that stand up and get Academy Awards and make their speeches about "when your peers vote," there's a real dimension of truth to that, if you really count the motives that people are bringing to a vote like that. In the Astronaut Hall of Fame, that's a group of solid folks and a meaningful vote. So that was neat.

Then I also was nominated, by one of my oceanography friends, Sylvia Earle, to the Women Divers Hall of Fame, and was inducted into that in 2005. A flying friend, Patty Wagstaff, several-time US aerobatics champion, nominated me to the National Aviation Hall of Fame [Dayton, Ohio], which I discovered when the certificate arrived in the mail saying, "We nominated you." The astronauts being inducted to that this year are Eileen [M.] Collins and Ed [Edward H.] White [II], which is a very good pair of picks. I don't know if I get looked at again. I have no idea. I honestly have no idea how these things work.

ROSS-NAZZAL: Quite the sampling of awards there.

SULLIVAN: Yes. It's fun stuff. They're neat. The events are sometimes very fun. Like I said, oftentimes they really introduce you to someone who comes to matter to you or teach you



something really neat in the long run. That's the real benefit out of it. Bullets on resumes are okay. So what?

ROSS-NAZZAL: Have you donated any items that they've used in any of the museums for any of the hall of fames?

SULLIVAN: The Astronaut Hall of Fame is the one that had requested things. I haven't. It's partly just not having gotten around to it. I did a pass through some of the stuff I have. A) I am not a great packrat, so I'm just not the person that's going to have every little thing I put my fingers on while I was getting ready for 41G. Of course early Shuttle is a different era than Mercury or Gemini, the range of things that we as crew members were allowed to take with us as personal mementos is way smaller. John [H.] Glenn's hand controller, the rotational hand controller from the Friendship 7 capsule, is above us here in this building. It's a one-time-use capsule. It's unequivocally his. When he says, "I had to steer this thing, I'd like that hand controller," they carved it off and they gave it to him. You try to take one of the hand controllers out of the Space Shuttle sometime, you're not going to get the same reaction.

ROSS-NAZZAL: Maybe when it's retired.

SULLIVAN: Maybe when it's retired. I think there might be a fight for that.

ROSS-NAZZAL: Is that something that COSI is considering once the Shuttle retires, putting in for one of the retired Orbiters?

SULLIVAN: I haven't really asked the current board chair or CEO directly. There's a pretty steep price tag to get ahold of one of those. COSI's charter and approach is really all sciences, multidisciplinary, not space per se. The priority in COSI's world of vying for just that artifact would be different than, say, the Reuben [H.] Fleet [Science Center] in San Diego [California] or the Seattle [Washington] Museum of Flight. Places like that, it's much more on their core mission, maybe even the Cosmosphere [and Space Center] out in Kansas. It's much more on their core mission to collect things having to do with space than it is for COSI. So I'd be surprised if they're bucking for that.

ROSS-NAZZAL: I had a list of general questions that I came up with. Some relate to items we talked about earlier, and I thought you might want to expand on. Then some are just general questions we ask everybody. We ask everybody what they think their greatest challenge was while they worked for the space agency.

SULLIVAN: I think I started in the program at age twenty-six, straight out of grad school. I think probably the greatest challenge I had was really learning personal and interpersonal skills. I had been a grad student working towards my degree. I'd worked on ships at sea, and that generates some of the same sort of mastering interpersonal skills, behavioral challenges of spaceflight, but nothing like the same close quarters and intensity level that the speed and pace and hazard levels of spaceflight do. It really almost was a cultural mapping of figuring out how the squadronlike culture of the Astronaut Office works. What are the behaviors and approaches that really make you an effective performer is the easy part, that's the intellectual competency part. Effective

communications, interacting with crewmates and colleagues, managing that. There's an interesting mix of colleague, compadre, and competitor that creates the dynamic of the Astronaut Office. Some of that was quite familiar to me. Some of that was alien to me.

I think some of that early transition at that young age, coming back from five years in Canada and into such a different setting, that was a big challenge. It was a great challenge. Some first lessons that became my own building blocks of how I look at and think about leadership. What does it take of you to be an effective leader? What methods and techniques and insights do you need to actually effectively lead and engage others? I think I really started building those more consciously there as I became aware of those factors and thought about them and reflected on my own practices and behaviors.

ROSS-NAZZAL: Can you share some of those details on tape?

SULLIVAN: On one level on any team, but in high performance teams, each individual needs to be fully known and highly predictable to the others. On another level, the team needs some creativity and flexible adaptability. I've always been a person that liked lots of variety and will often come at even the same thing sometimes in fairly different ways just to explore and experiment how does a different way work. Sometimes that's fine, and that was helpful. Sometimes that seemed to bother people. They were expecting you to do it just this way, and you try it a different way. Everybody was a little disconcerted. I had somewhat of a tendency to, if I spotted a problem, just dive in individually, fix it, and then step back out.

One that comes to mind is we were coming back to Houston in a formation of a couple of three T-38s. I forget now what the particulars were, but I was in the lead aircraft, which was to

contact base ops or hop off frequency and check weather or something like that. I went into my, “Okay, I’ll fix this mode,” hopped off frequency, checked it. I was managing the radios. The other two airplanes experience a moment of, “What are they doing? Where’d they go?” Just for the lack of either my saying, “Okay, I’m going off freq,” or my using effectively the other airplanes in the formation and saying, “Hey, number two, we’re leading the formation. We should stay in contact with our main flight control frequency. Hey, number two, hop off and check the weather. Come back and tell me.” I recognized there seemed to be an existing habit pattern and expectation pattern I hadn’t picked up on. My tendency, “I can fix this,” and just go off independently and come back, worked at cross-purposes with the group expectation. Things like that.

ROSS-NAZZAL: Is that some advice that you would give somebody entering the Astronaut Office, or just in general in terms of working at the space agency or anywhere?

SULLIVAN: It’s I think a general lesson about group communication. It’s a general lesson about using properly the role and the purview of leader and using all of the resources. In that case, that little formation episode, I hadn’t absorbed that me and the guy I was flying with, we are formation leader. These guys are resources for us to use. That was just a different way of thinking. That just hadn’t really crystallized that way in my head. My reaction was I hear it, I fix it; not, I hear it, and I assign it to be fixed.

That also was part for me of shifting from being an independent agent, where anything I need done is largely my responsibility. As a grad student I didn’t have staff. I didn’t direct staff. I didn’t have that kind of resource. You need it done, you get it done; not, you need it done, you

assign it, and then you manage the assignments. That shift to recognizing and understanding how to use your prerogatives and your resources when you are the leader, they are your resources, use them, and what monkeys to put on your back and what monkeys to put on other people's back. Those are pretty straightforward basic lessons of leadership, and in some pathways through life you probably learn them going through worker to supervisor and up the chain, or from recruit to ensign on up that chain. You'd learn it in smaller steps. My pathway had popped me in the side door at an advanced stage, and I was learning them on the fly early in my days in the astronaut corps.

ROSS-NAZZAL: What do you believe to be your most significant accomplishment while working for NASA?

SULLIVAN: Boy, I got to be part of so many amazing things during my fifteen years, it's just incredible. But the thing I would hang on my wall, and that makes me proud at a really deep level, is that I played some fairly meaningful roles in the Hubble saga, and was in on the early end, working with Bruce McCandless, Ron Sheffield, and that squad of people. Again, it's not a solo act, but to have been able to really make some meaningful contributions at the front end of establishing the capacity to service and repair Hubble, that is the essence of why it has generated the scientific results that it has. That would be a true statement even if we hadn't had to go through COSTAR to get there, but in particular, with the primary mirror flaw, the servicing capability, the robustness, and the preparation that our little cadre built from 1984 to 1990 just paid such dividends.

I say sometimes, especially to students, that you won't see my name on any of the servicing mission patches, but my fingerprint is on every piece of Hubble success that has ever happened, along with hundreds of other people who also don't have names on servicing mission patches. But it feels just as real and just as meaningful to me as if I'd been on every one of those servicing missions. I don't mean in saying that to take anything at all away from the servicing mission crews and flight crews. Each of them is an incredible challenge to master and deliver, but it's really gratifying to have given them the building blocks that we did, and to see the evidence that we built those building blocks really well.

ROSS-NAZZAL: I know I had emailed you about this maybe a month or so ago, and I thought it might be interesting to explore how women and women's networks have helped create your career. We talked to Ivy [F.] Hooks, for instance, I think in March, and she talked about how when you first came down she sort of adopted you for a while and made you a place.

SULLIVAN: She did. It was great.

ROSS-NAZZAL: So I was curious if you could talk about some of these women and their relationships and how they've helped you over the years.

SULLIVAN: Yes. Ivy was serving on Dr. [Christopher C.] Kraft's staff when our group interviewed. Interview week was such a mind-boggling blur to me. It was just incredible, chock-full of things, highly scheduled. These big figures in the space agency who were going to eventually make the decision, they were icons in the background. I'd interviewed in November.

We didn't get the word till round January. Not very long after that, I think maybe we had been down to Houston for the public introduction ceremony.

I'm home and back in Halifax [Nova Scotia, Canada], still in grad school. I get a note or a call from this lady named Ivy Hooks. It's not really ringing a bell as I look at this. She reintroduced herself, reminded me of where she was in that blur that had gone by. Just was tremendously generous and gracious. She said, "We live right near the Center." It's hard to move from Canada. I'm a grad student, am broke, haven't been in the States in five years. All those kind of factors. Not a small thing to uproot and move to a new city and get everything squared away. A house might not be ready. She said, "If it would be helpful to have a place to just land without worrying about things, feel free, we've got a spare bedroom."

I took her up on it and ended up spending four or five weeks in their upstairs bedroom and forming a really fast friendship with Ivy and her partner Bruce [G.] Jackson. They were both longtime NASA hands. Bruce, who worked for the NACA [National Advisory Committee for Aeronautics], moved to Houston after it had become NASA to help set up the new Manned Spacecraft Center—back when they were in a funky old building way up on the Gulf Freeway. They had great stories. Ivy had played some pretty significant roles in the aerodynamic engineering associated with the ALT [Approach and Landing Tests]. It was just a really neat fun first toehold.

They quickly became real true, genuine, who cares about the space agency, we're just person-to-person friends. Over the years, a safety valve if I really needed to just dump and vent. The friend who'll come scrape you up off the sidewalk when life has whacked you one, and pat you on the head, and send you back in for the next round of the battle. We're still in touch. It's episodic these days at this distance, but still in contact and good friends.

Carolyn Huntoon was also a notable figure for all six of us in those early days. She was on the selection panel. In the course of planning for this odd new class that was going to include these strange people, probably Ivy as well, but Carolyn, in particular, I think became I would say the voice of sanity and reason, as the otherwise all-male groups and teams of people would try to figure out how is this having of women around going to actually affect things. Sometimes on crazy funny levels, like gosh, “We’re going to have to divide the locker room in the astronaut gym so there’s two locker rooms in the astronaut gym. How big do you think theirs needs to be? How many of them do you think there’re going to be at the beginning? How many of them do you ever think there’s ever going to be? What do you put in the ladies’ locker room? It’s probably pretty simple to say I bet they don’t need urinals in there, but beyond that, what do you do in a ladies’ locker room?”

Carolyn now and then would tell us great stories, like going out for the walkdown to do the sanity check on what they’d come up with. Finding ladies’ side locker room towels that were fourteen inches by fourteen inches square and saying, “Maybe not. These are people who have hair. These are people who wash their hair.” What was it? The part of the locker room they carved off, fronted the building so they put some frosted kind of glass in there. They kind of forgot the fact that lots of times people are probably going to be in there either way early in the morning or way late in the evening dressing and changing, so we’re going to have all these silhouetted naked female figures. We probably don’t want to have that shadowbox show operating on the back side of the Space Center. There were some great stories like that.

When we showed up to get ready for these big public announcements—some of the gals had been the target of some media spots in the interview to selection announcement. Folks who were living in the US received a lot of interest and were featured on local outlets. Sally, and I



think Anna [L. Fisher] had been. I was lost in the woods up in Canada, so no one had found me. None of us had done a tremendous amount of media, and certainly none of us had the kind of focused attention that we were about to become. Carolyn gave us some really good advice before we got thrown to the media even that very first day.

She was a great den mother. We formed a bit of a group identity. It was not highly organized or orchestrated or anything else, but she jump-started us towards a recognition of some of the kinds of issues on which we might really all and each be best served by knowing we were operating from a group consensus. That really stood us in very good stead, and we carried that on well into the '80s. Just the number of things we really felt we wanted to cross-check with the other gals and know if we were in alignment, or get into alignment if we're not. It went down over time as we each established our own track record and established our own flight records. In those first couple of years, it served us well to have someone with Carolyn's wisdom helping us anticipate some of those things, be smarter than our years at how to deal with them.

There was not really a very explicit women's network of any sort that I recall around the Space Center. Everything was pretty coed, from softball teams to flight assignments. I've never much been one for just hanging out with the gals groups. I never joined Ninety-Nines, because I sort of get that kind of thing, but I'm a pilot. My interest is in being a pilot, not just being a female pilot or a woman pilot.

When I went to Washington I had two different circles, one an organized one and a more spontaneous one. A fairly large number of the science and technology posts, cabinet and subcabinet, in the first Clinton administration were filled by women. One of them, arguably the highest ranking, was one of the associate directors in the Office of Science and Technology Policy, M. R. C. Greenwood. Another in a prominent position was Anita [K.] Jones, who was

DDR&E, the director of Defense Research and Engineering in the Pentagon [Washington, DC]. Anita and M. R. C. took the baton on just starting a pretty informal periodic set of gatherings, usually dinner, sometimes a breakfast gathering. It was M. R. C. in the White House; it was Anita in the Pentagon, Sherri [W.] Goodman was in the Pentagon, Martha [Krebs], the Office of Science, the lab director at the Department of Energy. Carol Browner at EPA. So there were eight or ten folks in these different key positions.

We didn't know each other from before. It would be good if we came to know each other at a personal level and established some trust and confidence that if we ever needed to, as interagency issues moved through, we could with real comfort pick up the phone and come back channel and say, "We got an issue coming from our side that's going to hit your side soon. Heads up." Or "Can you give me any sense of how you're going to need to respond to it?" Or if you've got two interagency teams for your respective agency working, and they're not getting somewhere, to be able to go up to a near peer and say, "My guys are telling me X, and is that really what your guys are needing to do? Can we untie this knot so it gets moving, and get around the food fight that's about to start, or prevent the tie-up that's about to start?" We would just get together and do that periodically. That eventually included France [A.] Córdova, who became NASA chief scientist and is now at Purdue [University, West Lafayette, Indiana]. Cathy Woteki, who's now a leading scientist with the Mars Company. Quite a fun group of folks who've gone on but stayed connected in the decade plus since.

Then the International Women's Forum, a much more organized group, which came out of many of the same motives that I'm hinting at obliquely here. This goes back to Bella [S.] Abzug and some of the early women in politics, who realized they needed to be more intentional about constructing the kind of forum where women in leadership positions in government,

nonprofit, for-profit sectors really could, just like the story I just told, get to know each other and build some relationships in which they really gained confidence that they could trust. If they were encountering some issue from HR [Human Resources] to finance to personal career transition issues, they'd have an association, a network of colleagues from many, many disciplines, many, many fields, even many nations and cultures that they could draw on for experience. I joined that in DC in 1997, am still in that, and get a lot of value out of that. It's senior accomplished professional women in a remarkable rich range of walks of life from sixty nations around the world. A fabulous group of folks. I always learn something, always get something out of talking with them.

I've never been in an all-female professional group that's got that much variety and that capacity to really focus on the shared common interests, and come together really for learning and growth and supporting each other. Huge meetings on the international scale, and no one's just shilling their stuff or in sell mode. It really is in a very rich interesting exchange mode. It's quite good. So I like that a lot.

ROSS-NAZZAL: In our first interview you talked about Sally Ride coming to get you for the female toiletries kit, which needed another view. I was curious what was included in that kit, and what sort of advice did you give her on what was in there, what needed to be changed, or added.

SULLIVAN: This is the little spring-top toiletries kit, the dopp kit that would have your toothbrush and your toothpaste, comb or brush, the basic take it into the head with you to do your daily toiletries. Of course, the crew equipment guys had been packing those back since Mercury

and Gemini days with a razor and guy stuff. This was another one of those instances where there was this whole new odd set of questions to be dealt with. “What goes into the female one?” I think there were two such kits. One was the basic toiletries. I’m forgetting what the particular distinctions were. Everybody had like a personal hygiene kit, and a personal preference kit I think is what they were. The personal hygiene kit would be toothbrush, toothpaste, comb, or brush, etc. A personal preference kit was other items. I think it was the personal preference kit where if we wanted, we could have makeup. It might matter to you, if want makeup. Or if it might just matter to you when you’re getting off the Orbiter and there’s going to be cameras. We don’t know, but if you want it.

ROSS-NAZZAL: Was that manufactured in house? Or was that Cover Girl or something?

SULLIVAN: I’m sure it was commercial cosmetics. I’m making a wild and unwarranted guess here, but of the six of us in that first group, I would say with high likelihood we would probably break close to three on three, with three likely to be possibly interested and three utterly not. That’d be my bet. I would certainly be in the utterly not. Pretty sure Sally is in the utterly not camp—or was then. So off we go. They’ve packed up both of those for her. As I recall, it was in the personal hygiene kit, and I don’t know whether she had an explicit concern or issue in mind when she invited me along. I think she would have grabbed whichever one of the several of us she saw at the time. It was a moment of convenience thing. I’ve always suspected it was just on general principles. “Let me grab another one of the gals along and make sure there’s a second opinion here.”

I would have loved to have been a fly on the wall at what must have been agonizing uncomfortable meetings as this probably all-male group tried to figure out what feminine hygiene things do we need in this kit. There were a number of women techs [technicians] around; they probably consulted with them. I would just have loved to have figured out how these conversations went, because when we opened this up we found tampons. That makes good sense. They were laid out in that famous NASA in-flight pink plastic for packaging flight crew equipment.

I could just imagine that they would have laid out an eight-inch-wide band of this stuff, a hundred feet long, and laid a tampon down every however many inches, and then laid another strip on top of that, and heat-sealed every tampon into its very own little thing. Probably because the paper that they otherwise came wrapped in was deemed flammable by the flight safety guys. That would be my guess. So one by one, heat-sealed in a row, in Lord only knows how long the band of red plastic was.

Sally opens it up and looks in, and looks up at me with this rolling of the eyes that I had come to know as her “you have got to be kidding me” look. She reaches in and picks up this edge of this band of pink plastic, and now I can see tampon, tampon, tampon, tampon. Then she reaches the bottom of the string and pulls again, and it was like a bad stage act. There just seemed to be this endless unfurling of Lord only knows how many tampons. I’m watching this. We’re both starting to laugh, and mathematics is flashing through my mind. There are some things we know about this. This is a simple physiological process.

It runs on the monthly lunar calendar. It is typically only a certain number of days. These flights are going to be four to seven days long. We got some really smart math and engineering people around here. I would imagine we could do a probability calculation that

says, “What’s the probability that any given number of flight days goes right on the middle of any woman’s centroid of the period, and then what do you actually think is a plausible number of tampons anybody actually needs in a day?” The number we found didn’t seem to bear any resemblance to any such correlation. I don’t quite remember. It was her feedback to give. It was her bench check. I think I just fell on the floor laughing. I think we managed probably to be reasonably civil and respectful about it. That was pretty funny. “Not quite so many, guys. It’s just a bit overkill.”

Over and above the fact that another well known point, is that many women at high fitness and exercise regimes, which most of us were keeping up, menstruation eases or sometimes even stops, just as a function of the exercise and fitness level. Clearly, no one had thought about that.

ROSS-NAZZAL: Doesn’t sound like they had asked anyone. You’d think most of them had wives.

SULLIVAN: They’d sure not ever asked us. They had never asked us. They just put them in there. A lot. Put a lot in.

ROSS-NAZZAL: That would have been an interesting conversation, to explain, “We don’t need so many.”

SULLIVAN: That was interesting.

ROSS-NAZZAL: Another question that I had thought of. I don't think you had mentioned this. I think Jeff [Jeffrey A.] Hoffman had mentioned that Judy [Judith A.] Resnik had done an interview. The media had asked her if she thought that the feminist movement had played some role in her being where she was today, being an astronaut. She had thought that maybe it was her accomplishments that got her where she was. The headline read something like, "Women's Lib Did Not Get Astronaut Where She Was." What are your thoughts on that? Do you think that the feminist movement had some impact upon your opportunities in the space program?

SULLIVAN: I'd say probably some. I'd maybe go a bit larger than the feminist movement. We got our opportunity in part because of the point in time at which we all came along, and that point in time in American history was certainly shaped by the Civil Rights Movement. It was shaped by the '60s in general, and shaped by the feminist movement, absolutely. Someone smarter than me might be able to peel those strands apart and make more specific attributions of "these opportunities came from that part of the movement and these came from another part of the movement." I don't know how to pull those things apart. "Why is it so that Kathy Sullivan, Sally Ride, and Judy Resnik got the opportunities we did in the late 1970s, and Wally Funk and Jerrie Cobb and those gals didn't get them in the '60s?" Well, it's both.

It is both. I think this is probably what Judy was maybe responding to or pushing back on in her response. All of us, the Mercury 13 and all of us, we had skills and talents. We'd worked hard to develop them. We'd gained the certifications and accomplishments that we had. If the implication in that question was there's no individual merit in your being here, you're just riding a wave, well, I reject that. What I've invested, and the skills, talents, and abilities I've got, is certainly an important factor in why the opportunity is coming to me, but it's both. If I'd come

along in the timeframe of the Mercury 13, I suspect my course through life would have been much more like theirs. Not because I lacked skills or talents, but because the point in time culturally, socially, and civically didn't allow that door to open at that time.

When we came along, those factors had evolved, and the door was open. In fact, when we came along, if NASA had conducted a selection for astronauts that explicitly acknowledged needing scientific and engineering talent and then had come up with a roster that was all and only white male, I think there would have been a terrible outcry. It was not a tenable proposition in the late '70s that there are no people of color with the skills that you just mentioned. There may not be as many as Anglos, but it's just a nonstarter to assert that there are none that have reached high levels of accomplishment. It would have been a nonstarter to say, "I can't find any women that can perform at this level." The times were different.

That was certainly a factor. That doesn't erase the individual talents and accomplishments. Claiming and demanding some respect for your individual talents and accomplishments is not synonymous with totally rejecting that social change teed up opportunities that you were able to take ahold of. I think Judy was probably damned either way she answered that question. It's a much juicier headline to assert that she denied the feminist movement than to say she insists that you also respect her credentials. She more than deserved to have her credentials respected.

ROSS-NAZZAL: You've mentioned many times throughout the interviews that we've done about having a pilot's license. When did you get that license? Was that before you came to work for NASA?



SULLIVAN: I grew up flying little airplanes with our family, but mainly my dad and my brother, starting when I was about thirteen. My dad was not a licensed instructor, so he just coached us and let us handle the airplane, do the flight planning, learn it all as we grew up. Our high school graduation present would be to get turned over to a proper flight instructor with Dad paying for the flying hours, get any of his rough edges buffed off of us, authorized for solo, and continue on and get our pilot's license. That worked for my brother when he graduated in 1968. I graduated a year later, and the aerospace industry was going into a pretty big slump at that time. So with industry uncertainty and family finances, we put my plan on hold.

I went then up to Santa Cruz [California] to start my undergraduate degree and shifted into the sciences. The campus at Santa Cruz was fairly far removed from the one and only airport. I was working on a budget that wasn't going to have a car. As soon as I changed majors, I also had a totally crammed class schedule trying to catch up and complete my science major. What I've left out is the industry outlook and work outlook for my dad stabilized by something like the middle part of my freshman year, and so he encouraged me to get back up to Scotts Valley Airport. "Start back in. We'll get it done." My circumstances just never really made that practical: my own money, cars, all that Santa Cruz weather, coastal fog. It never happened through undergraduate. Then I continued my habit of going to coastal universities in foggy places with airports far away and no car when I went to Dalhousie [University, Halifax, Canada]. I spent five years there. Much of the good weather season in Halifax, I spent at sea. It never happened there.

I finally got to Houston in June of 1978, and fairly shortly afterwards got through the T-38 flying syllabus with "Bud" [H.E.] Ream and those obligations, and asked Bud to point me towards a civilian flight instructor. I wanted to get it done now that I had a car. I actually had a

little bit of money. I was right near a whole lot of airports with pretty good weather. Now I want to get this done. I didn't finally get the ticket signed off until I was twenty-six. I might even have turned twenty-seven by the time it got done up at Houston.

ROSS-NAZZAL: I was curious if you had had that when you applied for the astronaut class.

SULLIVAN: No.

ROSS-NAZZAL: In some of the previous interviews, you also talked about working with spacesuits before STS-41G. I was wondering if you could expand on that a little bit more.

SULLIVAN: The first step of that would have been I guess my first so-called technical assignment, I think right after we finished our candidate year. "Pinky" [George D.] Nelson and I were assigned to work with the WB-57F high altitude research aircraft program. That's a pressure-suited environment. Suits used there were the orange David Clark suit that, after *Challenger* became the LES (the Launch and Entry suit). Pinky and I both got full pressure suit-certified by the Air Force. Guys running the chamber out at Edwards tell me—I've actually never followed this up—but if they were right, they tell me I'm the first woman ever certified in full pressure suit by the United States Air Force. Go figure.

So we got certified in that. In '79 and '80 I think were the two years that we had that assignment and flew both Earth remote sensing and atmospheric sampling missions around the continental United States. I did a couple of stints up with a land mapping mission in Alaska. We

both went on a long deployment down to the tip of South America for the Southern Hemisphere air sampling. That was my first exposure to pressure suits.

My next assignment after that was STS-2 chase. The media assignment for STS-1, chase for STS-2. I worked at the Cape [Canaveral, Florida] as a Cape Crusader for STS-3 through 6. I worked the IUS [Inertial Upper Stage] payload on 6. STS-6, I'm pretty sure was my last flow as Cape Crusader, and I got switched over to being the general spacesuit person on EVA and spacesuit issues for STS-7. I would go stow the suits and rig the airlock. I had done the airlock closeout and stowage for STS-5 and 6 as well. Picked up the general suits, tools, EVA issues tracking assignment for the office around STS-7. I did that through I think 7. I got the STS-41G flight assignment in late '83.

I was working suits, got the 41G flight assignment that had the spacewalk on it, and rolled into training. It was a relatively short stint of being the EVA guy before I rolled into the flight assignment. Then on from there.

ROSS-NAZZAL: Were there any issues with the suits that you dealt with in particular?

SULLIVAN: Well, at that stage, there were always issues. Story Musgrave had been the primary engineering design evaluation office representative for the suit from its design days into operational status. STS-5 was going to be the first Shuttle EVA. Bill [William B.] Lenoir's suit had a problem. There's a sensor feedback loop in the fan of the suit that is driven by a Hall effect sensor, which magnetically can track the blades moving through and measure the fan speed. That problem that made the speed control circuit on the fan unstable. NASA proceeded with prudence and caution on the very first spacewalk with a new suit; they discovered that when

everybody was buttoned up in the airlock, that there were problems with the suit and decided, “We’re not going to go ahead. We don’t know if it’s a flaky fan or a flaky sensor. We’re not going to do that.” They waved off that EVA. That moved the first actual EVA to STS-6 with Story and Don [Donald H.] Peterson.

Those were the first two. The other big issue came before STS-1. It was one of the phases when Pinky Nelson was the suit guru. The event was during bench check, they take the torso portion of the suit, the life support system, and they plug all the ends, so they can pressurize it and run the suit at pressure and check that everything is working on a bench in the flight crew equipment clean rooms. They were doing that. One step of the procedure is you take the mode controller, just like you would do in flight, and you move it from the IV position where all the fans and pumps are running—and the suit is pressurized—you move it to the EV position, the go outside the door position.

The main thing that happens from IV to EV is a valve is opened that enables the emergency oxygen bottle. The isolation valve that shuts it off from the system is opened so that that 6,000-psi [pounds per square inch] oxygen flow is sitting on a regulator, ready to go flowing into the suit if the suit’s pressure drops. If you rip something on the suit, you don’t have to do anything to start flooding the suit with emergency oxygen. As soon as the pressure gets low enough, the bottle will start to flow. They moved the switch of the mode controller from IV to EV, and the suit exploded. The whole torso just exploded in a huge big oxygen ball fire that needless to say severely burned the suit tech that was working on it.

There was obviously a detailed investigation to figure out what had really happened. Boiled down to some subtle but significant factors in the shape of the channel that that high pressure oxygen flows through, and the likelihood that there was a little bit of residual organic

matter. The suit had not been really fully properly cleaned. You slam a bunch of oxygen on there, increasing pressure heats things up, and there's just enough organic stuff there to be volatile, and kaboom. Needless to say, any of us working on suits were saying, "That's the same thing I do inside the airlock in orbit right before I go out, and we just blew a suit up doing that?" If you're doing some weird test that's unlike anything that you normally do in suit operations, it would still get your full attention, but this was like saying when you step on the gas of your car it's going to explode. Highly discomfiting.

Those were the big things going on. The other issues that would come along were more the operation and procedural issues, and helping guide efforts to think ahead about what tools you might need. If you ever needed to unbolt an entire payload assist module cradle from the payload bay and throw the whole thing overboard, what would it take to get the launch bolts undone? Trying to think those through, and run the evaluations to make sure can you do that. Can you develop a tool that lets you get at the interface and work it? And then are there torques or forces involved that are going to need an astronaut to put so much full body strength into it that you might overstrain part of the suit.

ROSS-NAZZAL: Were you ever working any sort of issues in terms of body size in the suit? Some of the astronauts were rather small. Or Ox [James D.A.] van Hoften was rather large.

SULLIVAN: Yes. The issue of building an extra large HUT [Hard Upper Torso] to accommodate Ox got folded into things pretty early on. I've always suspected that management's decision that he was going to slot in on a spacewalk must have been premade fairly early on, because that

went by just quick and early, and was really entirely a management and program configuration issue.

The small suit issues had really not come much to the fore. Anna Fisher had done some fair amount of work in the suit. Now this may have been in Shuttle EMUs [Extravehicular Mobility Unit]. It may have been in leftover Apollo A7L-B suits. My first underwater engineering work was done in Apollo suits because the Class 3 Shuttle EMUs had not been produced enough yet. So we were still doing the work in Apollo suits.

There was a fair amount of engineering development work around tile repair in the run-up to STS-1 and 2, with Bill Lenoir, Anna Fisher, and other folks in the old little coffee can, the WET-F [Weightless Environment Test Facility] out on the back lot at JSC, before we all started going over to Marshall and using their WET-F. Anna had done a lot of work there. I honestly don't recall any significant discussions or gripes about suit size coming out of that work. That was the same time that I was off flying WB-57s, so that may be an artifact of my having been engaged in something so different and not really tracking the conversations that closely. I don't recall big, fraught discussions or high level issues about suit size from that.

I get the nod for the 41G EVA, and they start fitting me up for the suit. There were some points of the suit that just never fit. The one that'll make anybody unable to work effectively really is the hard upper torso. The two key factors there are your shoulder width compared to the placement of the shoulder bearings, and the depth really of your chest cavity compared to the front-to-back dimension of the suit. The scye bearings, as they're called, that let the shoulders move are pretty large bulky complex assemblies. Physically there's only so close you can put them on the hard upper torso before they'll start to impinge on each other and not work. Secondly, the front of that hard shell is the acreage to mount the display and control module on.

If you pull those shoulder bearings too close together, you don't have anyplace to bolt the controls on.

Then the front-to-back dimension, that may be one issue of body size. It is argued that the problem of front-to-back dimension is only something that will affect you in training, where if you roll on your back to do a task, and if the suit doesn't fit you firmly tight front to back, you'll fall back in the suit so that your back is physically contacting the back of the suit. Well, that means your fingertip is going to pull back away from the glove, and you won't really have your hand in the glove and be able to do something. There's no reason to think small frame people can't perform well in zero gravity when that falling to the back of the suit phenomenon wouldn't happen. The issue is it can make it impossible to perform effectively in training. It can make it impossible or extremely hard for you to demonstrate top competency at EVA tasks in training if every time you reorient your body, your hand may come out of the glove. You can't grip and work effectively. That's where some of the complexity of the argument comes in.

Some folks—not many, but some people would say, “Since it's just a training issue, you should certify and fly small frame people anyway. It's an aberration in training. They'll be fine in orbit.” The counterargument would be, “We're placing a lot of responsibility for delivery of outcomes on an EVA crew.” You are or are not going to have a properly configured Space Station at the end of this EVA. You are or are not going to have successfully repaired Hubble at the end of this EVA. If I'm training six people as candidates for that task, and I can see five of them perform it superbly under water, and I never get to see one of them perform it well under water, you're asking me to risk the program on the guesstimate, bet, that the fifth person who I have never seen them do it super well. That may be because of the suit, but the fact remains I have never seen them do it super well. I have five other candidates who I have seen do it super

well. How can you expect me responsibly to pick the person I haven't seen perform? I wouldn't. You have to live up to your responsibility to the program.

The torsos fit me well. I was almost getting bruised getting in and out of the suit. If I inflated my chest really fully, I would feel the hard points on my ribcage, on the sides, and could feel it front to back. So it's a good incentive to keep your breathing nice and even. My ring finger and pinkies seem to be—especially my pinkie—unusually a notch shorter than the other three fingers. Could never quite get the pinkie tightened down. You want to size the glove so that your thumb, index, and middle finger are snug in the glove, and if your ring finger and pinkie don't quite fit, that's okay. You lose some grip strength, but it's the three that make up your lobster claw that you need. We could get those, but I could get floppy fingers on the other two.

The placement of the mechanical elbow should be right lined up with your anatomical elbow. Mine was always about an inch and a half or two lower. When I wanted to bend the suit arm, I wasn't actually pivoting it. It was like bending a balloon. I had to force the lever, so it took some extra strength to bend that. I adapted to that. Then, the section of the lower torso from the body seal closure to the hip bearing has a particular name, but I've just forgotten. It's that first slice of the suit from the body seal closure down to the hip bearing. That comes in a couple of different sizes. They put the one in there they thought ought to fit for me, but it actually didn't. The result of that was my knee also never actually lined up with the suit knee. Same thing. The joint of the suit was below my anatomical knee. So it wasn't a nice easy bend here. The suit would actually hit my calf, and I would have to push around the corner to make the knee bend. I reverted to my notorious tendency of, "It's your problem, so deal with it."



Secondly, I made a considered judgment with respect to EVA flight rules and with respect to suit fit that the first thing we needed to do was just get to a point where we did a successful EVA and demonstrated this all works just fine. I reckoned the wrong thing to do was to turn the first evolution of a woman doing a spacewalk into controversy over, “We need different flight rules and oh, see, now she’s asking for more equipment.” I just sucked it up and dealt with it. The guys recorded that things never quite fit. Order a new lower torso assembly? “No, we’re just going to deal with this.”

I was actually training up for I think 45. A new round of suit techs was in and looking at the fit. Somebody actually commented to me, “Is this the fit you’ve always had?” “Yes.” “Your knee doesn’t fit right.” “Yes.” “We don’t have your elbow fit right.” “Yes.” “We ought to do something about it. It ought to fit you right.” I said, “We can start that conversation now, but if you think I was going to make that the conversation on the first EVA you’re crazy.” So I just dealt with it.

ROSS-NAZZAL: I’m glad you said that. I’m glad that that came out. You did talk a little bit about being a Cape Crusader. Who came up with that term? No one’s ever told us the history behind that phrase before.

SULLIVAN: I don’t know that I know the history behind it. I don’t know.

ROSS-NAZZAL: It makes me think of Batman.

SULLIVAN: Yes, but I can't tell you. I only know it in the Shuttle context, but I wouldn't be able to guess. I never heard anybody say, "That's what we always used to call the support crew at the Cape in Apollo." I guess I've been operating on the assumption that it was something that popped into existence in Shuttle days, but don't know.

ROSS-NAZZAL: Yes, I think so. Is there anything more you want to say about that? You talked about Don [Donald E.] Williams and the issue that you had with the condo and the key, but you didn't say much more beyond that. I don't know if there's anything more you want to talk about.

SULLIVAN: No. The whole condo thing, after that little bit of episode back in the Houston office, it evaporated pretty quickly. It was no issue. Again, it just worked fine. We all parked gear there. We came and went as we needed to. STS-3 was the first one. I worked STS-3 payload integration and STS-4 payload and crew equipment integration. Loren Shriver and I were the exchange crew out at Edwards. When TK [Thomas K. Mattingly] and Hank [Henry W. Hartsfield, Jr.] got off, we got on, saluted those two guys, they got off. We babysat the Orbiter as they towed it back around to the lift, put it on the 747.

STS-5 was integrated spacesuit stuff. STS-6 was the first flight of an integrated upper stage and payload. The other thing that I was doing through the STS-4 and 5 flow was working with the IUS team. We had a dummy payload that we were walking through the whole processing cycle just to make sure all the lift structures worked correctly, all the access platform clearances worked right, all the test equipment that had been built to do the preflight test and integration on that upper stage actually worked right. We ran a complete dummy payload through the VPF [Vertical Processing Facility] processing flow, finishing far enough ahead of

STS-6 that we could debrief and incorporate all that and then bring the real payload in. No one had ever written those procedures, dry-run them, checked them. That was a pretty big body of work.

Then launched and flew that. That flight slipped and bounced around quite a bit. I think it was originally set to go in something like October of '82. When it eventually went, it was April of '83. Got it all launched, all the late hours and things that that involves. I think I stayed out at the IUS side of the control center to watch the deploy and I think the initial burn, and finally went back to the condo and crashed in bed. I remember I got up the next morning, and Ox van Hoften was in the living room. I walked into the living room, was still bleary-eyed. He made some comment like, "What the hell went wrong with your spacecraft?" "What?" Something had gone wrong. I think the upper stage didn't fire full duration, and they had to use more of the payload propellant to get to an operational orbit. That had happened on the second burn after I was dead asleep in my bunk thinking, "Oh thank heavens it's on its way! It all worked. It's just fine." I get up in the morning and Ox goes bam, "Nice payload! Lost a satellite." "What? Oh, that's not what I needed to hear first thing in the morning."

ROSS-NAZZAL: Do you want to say anything more about mission development? I think when we started talking about some of your early career we skimmed the highlights, but I don't know if there's anything more you want to say about that. Like I said, I went through, noticed a few things that we hadn't talked a lot about in depth.

SULLIVAN: Yes. Nothing really stands out of the mission development stuff. The Astronaut Office fanned so many people out to support assignments to make sure that the technical support

and intelligence gathering operation is really working. That we've got the right issues moving, fostering the right communication so we're getting heads ups to crews or spotting emerging issues that need a broader consideration at a policy level. So it's fun. You get a broader overview of the many, many things going on than when you're just tracking a payload or just working at the Cape. So that was fun, but I don't recall any particular standout issues that came up in that timeframe. Again, I'd have to go back and remind myself what the years were and where that sits in the flight sequence.

ROSS-NAZZAL: One other question that I had relates to in-flight clothing for the women in particular. How was that handled? Was that an issue like that in-flight toiletries kit?

SULLIVAN: Lingerie?

ROSS-NAZZAL: Obviously you wore the polos.

SULLIVAN: Yes, the outerwear standard stuff. I'm just trying to remember if this was the way it was the first time Sally flew; I think it headed down a different path and then got adjusted. Maybe informed by their success with tampons—bra and underwear things, it's just different. People have certain preferences, styles, and comforts. Even when there's six of us, much less when there's going to be more than six, it's silly to go make a standardized decision for women's lingerie.

I think the program started first to go down the, "We will order—like we do for the guys—briefs or boxers. What more is there, we'll order this or that, you guys pick." This is

really a bad idea. So what came back around by the time I flew was a set of specs [specifications], restrictions, on basically the kinds of fabric and designs that were acceptable from flammability and other point of view. Then it became, “You go buy what you want, charge it back, and it will be yours, what you want, your fit. Then we’ll stow it, as long as it’s cotton and this and that. Just stay in those bounds, go get what you want.” Fine. We’ll do that. That sounds a whole lot better.

ROSS-NAZZAL: Much better than a NASA engineer or tech coming up with their own design.

SULLIVAN: Oh yes. Oh, it’s a frightening thought.

ROSS-NAZZAL: That could be something you could put on eBay. Looking back over your class, you just had your reunion here, what do you think are some of its accomplishments?

SULLIVAN: Oh, wow. [Daniel C.] Brandenstein and company actually pulled some of that together. Shame on them. They haven’t gotten a summary of it all back out to us.

ROSS-NAZZAL: That’d be nice to have.

SULLIVAN: Yes, that’d be fun to have. Boy, a lot. Just such a lot. Starting with we got there before even STS-1. A number of us in various ways got to play some pretty intriguing and significant roles in helping the final stages of that happen: CapComs [Capsule Communicators] and engineering support. It was pretty neat. I always thought we got an unusually good deal to

get to be there. At the time I think we all thought, “You told us this was flying in a year. Is this ever going to fly?” Once you get past that and look back, that was a really neat part of the experience to get to be there at the final stages of the dawn of the program.

Some of them are just obvious straightforward things: first American woman to fly in space, first African American, first Asian American, first woman spacewalk, Space Congressional Medal of Honor to Shannon [W. Lucid]. At various times, duration distinction. Shannon for a while had the longest US duration. That’s one of the records you hope will fall quickly because the durations will grow, but a nice thing. Satellite rendezvous, release, capture, regapple, free-flying payloads. Satellite repair and rescue: the Solar Max stuff, the PALAPA/WESTAR stuff was on our watch, a bunch of our guys on the crews. Hubble Telescope. Spacelab. There’s a lot in there. Then if you track what folks have done since then in various program assignments, whether it’s [Richard O.] Covey on the Covey-Stafford Commission. There’s been so much of that, you lose track. I served on the National Commission on Space. Sally had a task force report assignment that became the Ride Report. Covey with the Stafford Commission. Sally a key front of the table role on both of the accident commissions, and a number of others of us on technical teams feeding into those processes.

I guess if you look at FCOD [Flight Crew Operations Directorate] leadership, you see that has evolved. It evolved from the Apollo/Skylab era in anticipation of Shuttle, and our group coming along and through the lifetime of the Shuttle program. As you see Station and Russia and other things coming at those kind of junctures where the office is shifting again, shifting towards a more conscious focus on the real factors that affect long term flight, shifting to a more conscious focus on the political, cultural and other realities of close international collaboration. That kind of evolution started and much of it happened with our classmates sitting at FCOD,

sitting at CB, sitting as deputy center director, now sitting as JSC Center Director [Michael L. Coats]. We've had Center Directors. Our class has directed Kennedy. It's directed Johnson. There's a lot there. There's a lot there.

ROSS-NAZZAL: Pretty impressive.

SULLIVAN: Yes. It was a pretty good group. It's a pretty good group.

ROSS-NAZZAL: Did you get a chance to go down for Eileen Collins's flight when she was the first female commander on STS-93?

SULLIVAN: I went down for the big administrator's women in spaceflight get together and for the first launch attempt, the one that scrubbed. I was there for that. I did not get back for the actual flight. Not too many weeks after landing, there was an event at the White House that Mrs. [Hillary Rodham] Clinton put on. It was an interesting event. Eileen was the main focal point. But she also interestingly—and I railed against this initially—paired Eileen Collins and Kate Mulgrew, the actress who plays the Starfleet commander in the *Star Trek*. Paired them as both a real and a public imagination icon of women in command on the space frontier. Then had other notable female scientists and engineers.

It turned out actually to be a pretty interesting event. The pairing of the fictional and the real commander actually was built better and worked better than I initially thought, I'd say in large part because Kate Mulgrew was pretty eloquent about what she had gotten out of the day. She had a really insightful and anchored kind of perspective on what she's learned and what her

challenges have been of trying to represent this character who's commanding a major vessel and all the circumstances that the show brings, when she in fact hasn't got a technical training and hasn't been in those kind of leadership roles. The effort she's put into it, the glimpses, and things she's felt she had learned through the character about those challenges. Then to have the day to meet these women who have commanded naval vessels. It was a really interesting soliloquy on reflecting back and forth between those two experiences. Very humbly, modestly, and sincerely full of, I think, effusive respect for the actual real women who do this who she had a chance to meet today. It really was kind of neat. I had a chance to see Eileen there, but didn't get to see her go. If she'd left on time! We were there. We were ready.

[End of interview]