

**NASA JOHNSON SPACE CENTER ORAL HISTORY PROJECT
EDITED ORAL HISTORY 3 TRANSCRIPT**

KATHRYN D. SULLIVAN
INTERVIEWED BY JENNIFER ROSS-NAZZAL
COLUMBUS, OHIO – 12 MARCH 2008

ROSS-NAZZAL: Today is March 12, 2008. 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 taking time to meet with me today.

SULLIVAN: It's a pleasure always.

ROSS-NAZZAL: Last time we talked about Henry [S.F.] Cooper's book [*Before Lift-Off: The Making of a Space Shuttle Crew*], and I wanted to start today talking about your EVA [Extravehicular Activity] and the female Soviet cosmonaut that went out and did a spacewalk before you did.

SULLIVAN: Yes, those were very interesting times. When our crew was first announced, and I always have to reconstruct in my head the timing of this, I think I first knew about our assignment, something around August of '83. I know I got a phone call from a crewmate, from Sally [K. Ride] actually, while I was just coming out from a backpacking trip, and that gave me my first heads up that there was going to be an assignment. I think the official word came out some months after that, perhaps maybe as late as the October/November timeframe.

There was this delightful wave around the Space Center and around the Astronaut Office of folks all excited and happy for you, like you always get with a crew assignment, and a little

extra buzz, because we were the big class of people. We were all cycling through our first assignments so there was a lot of excitement about that. Around this assignment there was the extra little buzz that Sally and I got, because at first blush it appeared that Sally was going to garner the distinction of being the first woman to fly a second flight. You can do stunts and fly somebody once, but one stays in the game and is flying multiple times, that tends to indicate this is a real deal, and these are real players, not come along for a stunt ride kind of thing. Sally would get the distinction of being the first woman to fly a second flight, and I would get the distinction of being the first woman to do a spacewalk.

It may have been the very first time, certainly the first time that I recall someone we both knew ran up to us and accosted us with their excited congratulatory eagerness about all of this. I'd really never given this that much thought until just that moment, not consciously anyway. This person runs up to us full of excitement, and I think Sally's head and mine, each pivoted towards the other one at about the same rate. Our eyes met, and there was just this exchange of looks of complete comprehension. Just about simultaneously we both said to that person, "No, you have not been paying attention. It's only November."

I think at that point we were slated to fly in August, but we flew in October of '84. The flights juggled around quite a bit with the failures of the PALAPA and WESTAR satellites, so I'd have to look back at precisely what the manifest was at that moment. Our flight date was many, many, many months away. So we basically looked at this person and said, "No, you have not been paying attention. It's a very long time between today and that flight date. Let me just promise you a Soviet woman will fly a second flight and get a spacewalk." They are very conscious about making sure they do these observable obvious things consistently and have a long proud list of Russian names in the record books. I just think that—can't speak for Sally,

maybe she agrees with this all out—it was almost spontaneous for me, realizing, “Oh no, that’s not going to happen!”

Where was any woman in the Soviet space program from Valentina Tereshkova in 1963 until just a few months before Sally's first flight? Nowhere to be found. Not acknowledged, not evident. Near as any westerner could tell, that I knew of. None present until there's about to be an American woman flying on a Space Shuttle, and suddenly there's another Soviet woman flying. There's no way that Sally's going to get to be the first woman to fly twice, and there's no way I'm going to get to be the first woman to do a spacewalk. Second is not bad, and the first American is not bad, but you guys are not watching what's going on here. I think we're both going to get to be second, and it was quite amusing.

ROSS-NAZZAL: That's interesting. So no disappointment, you knew that was going to happen.

SULLIVAN: No, I was really not disappointed about where in the big grandeur of the history books things would end up. It's just such an amazing thing to be a part of what we were a part of anyway. I'm as eager, avid, and in various ways competitive as anybody else. Eager to go first, to get to do novel things, to get to expand my skills, and test myself against new challenges, but I'd never really been very much driven by what I call the peanut gallery. There's always a peanut gallery watching what you're doing. You're simple fodder for their entertainment and gossip, and it's just idle chatter to amuse themselves. Always figured you're crazy if you're steering to them. So I didn't ever really steer very much to that.

The other thing was quite honestly I could have been the 50,000th or 100,000th woman or human being to do a spacewalk. In terms of the broad historical backdrop, it still would have

been my first spacewalk. I honestly can't think of anything I would have done differently in how I went about it, how I prepared for it, how I was processing the meaning of it to me and to the mission, and to everything else. I just honestly can't think of anything that would have changed because of where in some external sequence and ranking we would have been. You don't do the fourth mission worse than the first one just because it's not a first. It's a nonsensical proposition.

You have this extraordinary opportunity. For starters, you swore an oath to serve your country: this is not you got your agent to get you a gig. You swore an oath to serve your country. You're surrounded with people who are putting their career aspirations, equipment, and hardware in your hands. You are their proxy. I just don't know how you come to thinking that the seventh, tenth, or thirteenth of those is less meaningful and less deserving of your good efforts than some historical first. That's just never made much sense to me.

We knew that was going to happen. There ended up being another little wrinkle when we got into the flight, centered on the duration of the spacewalk, because come July of 1984 when sure enough Svetlana [Y. Savitskaya] took off again on the Soyuz and went up to the Salyut station. And, oh gosh aren't we surprised, she went outside and did a spacewalk demonstrating some vacuum welding gear. As soon as that was over, all my EVA trainers and folks were racing up to me and saying, "Well, her spacewalk was only three hours and thirty-four minutes or whatever, three and a half hours roughly; a little bit more than that, you'll get the duration record!"

Our spacewalk wasn't going to be a seven- or eight- or ten-hour spacewalk like Hubble servicing or Station assembly, it was an engineering test, just as Svetlana's was. I thought well, that's pretty small and tacky if you're going to rejoice in having a three-hour-and-thirty-seven-minute EVA instead of the three-hour-and-thirty-four or whatever the numbers precisely were.

If you really got your head on straight about this, wouldn't you be thinking about it more the way I had always imagined as I watched the Olympics? It would have to be fabulous to put in a personal best or an Olympic or world record in the pool in a relay race or on the track. You should be proud of that. It's cool to be a record holder, I guess, but if you really care also about the sport and have a sense of perspective on the march of history, you'd be curious about well, who can come along next and when will this record fall. In a sense you ought to expect and almost want progress to go on and take your record down. It didn't strike me as a really big thing to beat her by a few minutes. I'm certainly not going to go tromping around on dinner speeches or something saying, "Well yes, but I have the duration record," because it's all of the same order. It's just silly.

When we actually were outside, David [C. Leestma] and I, we had trained so much to hit the timelines, because one does that as a matter of principle, but also in our case our being outside required that the major payload, the Shuttle Imaging Radar, be turned off. It was EVA at the expense of radar, because of electromagnetic interference factors. Given that, there was a lot of push from the radar guys to hold the EVA timeline as tightly as possible so that you don't destroy even more of their data takes. We'd gotten a very strong discipline embedded in us and a good cadence to the whole EVA to get out there, get things done, tidy it up, come on back in. Even though, when the spacewalk ultimately did get scheduled, the impact on the radar in terms of data was much much less severe for a host of reasons, including some failures in the Ku-band system, so that really almost wasn't a factor on the day we actually did the spacewalk.

The fact that that constraint didn't matter as much I don't think really registered to either of us. You get out there, and the adrenaline's going. It's real zero gravity, it's not the pool, and you tend to move through timelines better on orbit than you ever did in the pool. We just

knocked the thing off in very short order. I learned when we got back the EVA flight team was actually watching the duration clock very carefully and was very mindful of where we were relative to Svetlana's time. They either had composed or were trying to figure out, how do you compose a flight note to go up on air-to-ground that isn't quite as tacky as "stay out for seven more minutes so you beat her." Trying to send a stretch signal in some quasi-diplomatic way. I think our duration was like 3:29 and hers was 3:34, so it was a five- or six-minute difference, and in the wrong direction as far as they were concerned. That was the melodrama around the spacewalk and spacewalking records.

ROSS-NAZZAL: Tell me about the spacewalk, getting ready, what it felt like to go outside for the first time, and the spacewalk itself.

SULLIVAN: I'd been working the spacesuit for a year or so at least before we got the flight assignment. So I'd been in the middle of and followed quite closely the experience on STS-5 trying to get outside. A fairly seemingly small technical matter, the Hall effect sensor that helps control the fan speed had been flaky on Bill [William B.] Lenoir's suit, and that was going to be the first Shuttle spacewalk. So it's uncertain if they would go out. You want to really diagnose this carefully and be positive. They waved off. They didn't go out, and STS-6 became the first Shuttle spacewalk.

You get in the middle of the trenches looking at and being conversant with all the technical detail and, I guess with a rookie's mindset as well, part of me was just hyperaware of how many tiny little things could go wrong. Dave too. We would caution each other, bracing each other that this might not happen. It's a spacewalk; the system is still ginchy about

spacewalks. These are big evolutions. It's risky. [Robert L.] Crippen approved it of course, but also has a real dose of caution in him as well. The system's got a little bit of inclination to tip towards "let's just not do this," especially if it's an elective thing like an engineering test.

Part of me was eager to go do this, and the suits are a ball. I love being in the suit. I love working with it in the tank. I just adore all that stuff. The thought of actually getting to go outside, cruise around the payload bay, do our engineering test, and glimpse the world below me without a window frame, all that's just outrageously cool stuff. Of course by the time we get to our spacewalk there've been the fabulous evolutions of the Solar Max rescue, and our buddies flying off from the spaceship on the MMUs [Manned Maneuvering Units]. In part I'm envious, "Are you sure we can't turn our spacewalk into one of those? Can't we just snag an MMU? Don't we have some more flight tests that need to be done?" No spacewalk is paltry, but really three and a half hours to crawl outside and work with this fueling mockup is seeming a little meager compared to what those guys got to do. "It's not fair. When do we get to do that?" All that's swirling around in a sense.

Then of course we had, pretty early in the flight, the short circuit on the Ku-band gimbal control, which really just knocked over a whole bunch of the dominoes. The whole complex interlock of data takes from the major payloads was shredded by that, because they had to completely rethink how they were going to take data. Again I'm a rookie, had not worked in mission control at that time, so I'm watching the whole interplay of our crew and all the flight rules we put together pre-flight on the ground, in real time, and following how it's going along.

I wasn't sure I had a clear positive sense yet of how the ground was thinking about this. It was great to have Sally and Crip along, because they've been through a flight evolution once before. It's as if you now know your friend or you know your colleague, and they had a bit of a

sense of, “this is how the guys on the ground are going to be thinking about this.” I could reason through and imagine several ways they might be thinking about it, but I didn't yet quite have the confidence that, “I'm sure they will come to this kind of conclusion” or “they ought to come to that one,” and “I need to steer them there if they don't.” We have this pretty disruptive event, minor, but pretty disruptive to the flight plan, happen early on. We're looking at all the flight plan changes come up. The EVA just starts sliding down in the timeline, and of course as things slide down the timeline you just worry about other events that could crop up between now and then that push it further down the timeline or take it out of play.

There's nothing you can do about that. It was an eight-day mission. We had plenty of things to do each day. You just keep trucking on, but in the back of my mind there was just this, “Do not take for granted that you actually get to do this. The world's not going to give it up easy. You're going to fight for it. Bird in hand is always better than bird in the bush, and this one's just moved further, deeper into the bushes.” This is not what we wanted to have happen.

There's a normal ground rule about not doing spacewalks the day before entry. Before too long we're pushing up against that. There are not that many days left. Are we going to go do this or not? It's going to take some overriding of the normal flight planning constraints to still fit this thing in. We spent five or six days just stewing with all of that in the background and going on about the rest of our business, before we finally got to the spacewalk part.

The Ku strand of the story connects back in the sense that the factor that was driving the spacewalk down late into the flight plan was that we had disabled one of the motors on the Ku-band assembly. You want to use that antenna as much as you can for the radar. On entry day you have to swing it back inboard so the payload bay doors can close around it, but one joint is disabled. That's one of the joints that's critical to positioning it so the whole assembly can be

locked into its return-to-Earth configuration. How are we going to optimize all those things at once? I want to use it as long as possible; I don't want to damage the antenna or the payload bay doors coming home. I somehow have to position the silly thing so that I can lock it. Oh, that's right, I'm about to have people out in the payload bay, somebody could actually go manually put it where it ought to be. The ground used a couple of days to choreograph that new evolution into the spacewalk.

It was going to require Dave and I to position ourselves at two different places in the payload bay. It's going to require me to improvise a pathway from the port sill to the starboard sill. It was going to require Sally and Jon [A. McBride] and Crip to go back down below, tear out lockers, get out a connector and put a jumper across one wire so that the two locking pins would close. When the antenna first failed, we had disconnected a multi-pin connector so that the motor wouldn't drive continually. Now we had to undo that connector again and jumper across the circuit that would close the stowage locks. All that had to be choreographed in and thought through so that we could complete that before coming back inside.

This was in the olden days of the teleprinter. Nowadays if you wanted to communicate this with a crew on the station you'd upload a file on e-mail. It could include an image, it could include full high-fidelity circuit diagram, and you could put people in the water and take pictures of what they were doing in the NBL [Neutral Buoyancy Lab]. Really give the crew on orbit a very clear sense of, "It's this device; it's going to look like this, and here's what the geometry will be in the spacewalk." Back then it was dot-matrix printer teletype trying to graph out a design. The folks in mission control were actually pretty adept at drawing cartoons on the teleprinter that were remarkably expressive of things.

We got all of that done as well over the ensuing days. I just remember from what was meant to be, I think, a day five EVA to what became a day seven of an eight-day flight. So day before entry finally it's coming around, and we're going to go do this. It was just really great to start into the pre-breathe protocol, the 10.2-psi [pounds per square inch] cabin pressure. You practiced it. You've done it on the ground, and it never quit being fascinating to me how completely familiar those big evolutions could be, because you'd done them so much. And yet how intriguing it was to just have this awareness that "but this is the real environment. This is for real and isn't this amazing? Here we are. Now we're actually on orbit hundreds of miles above the Earth doing this for real." It somehow feels surreal that it is so natural, the feel. Yet such an amazing thing to be doing in such an amazing place. Those twin awarenesses side by side never cease to amaze and delight me, all the time I got to spend in orbit.

This was the same thing. Now Davey and I are now finally keyed up, getting our gear out, polishing up helmets, and doing all the checkouts. Just really hoping everything just goes off just as it should, and it largely did. Then suiting up the next morning with Jon helping us get our gear on, and Crip swimming around the cabin with the extra crew member called the IMAX camera, which is this huge honking piece of gear. We had three crew members, two full EMU [Extravehicular Mobility Unit] assemblies, all of the bits and parts of gear that are going to become two suited crew members scattered around the middeck, and Crippen swimming through with this gigantic camera catching a couple of scenes for *The Dream is Alive*. We had talked that part through when we were doing ground training, but you can't hoist the camera up by the overhead of the middeck. That would normally just be a verbal, "Okay right about now," Crippen would say, "I'd be bringing IMAX along. This would be the part of the suiting up we would film, and Jon, if you're going to be over there I'd probably go over here." You'd roughly

mentally block out what was going on. We finally got ourselves all stuffed in the suits and trying to work down along the timeline.

There are two airlock repressurization-depressurization valves, one from the cabin to the airlock, one from the airlock to the outside. There's a dustcover on each one, so it's actually got a valve open or closed and then on top of that just another fairly deep cap, a couple inches deep. It turns out those things run on a pretty fine-pitched thread and are honked down pretty hard on the ground by the guys that are preparing the vehicle for launch, because it's good to have one sealed firmly. It doesn't help you to have one running loose. I remember we lost some amount of time, because the one from the cabin to the airlock is recessed into the outer housing of the airlock in a way that gives you not much purchase on it. You really can only get your fingertips on it; you can't use the whole palm of your hand. Even someone as strong as Jon McBride, it took him a goodly while and some pretty hefty work to actually get the thing running loose and open up. I think that put a twenty- or thirty-minute delay into getting outside.

Then the magic moment comes, and again although you've choreographed all of this, you just feel the momentousness that this is now actually for real. Jon unhooks each of us from the adapter plate on the wall that's been holding up our backpacks and giving us a structure to work against. Some crew members do both folks vertical in the airlock front and back, and some do up-and-down. David and I had decided that we stratified the airlock vertically, and so Jon positioned me with the EMU backpack up against the upper surface of the airlock and Dave beneath me with his chest pack towards the deck. Both of us had our heads facing aft. Then Jon seals up the inner hatch, and we're now on our own.

Of course we've still got a little more time to go. Then finally we dump the airlock down to five psi and start to hear the suit actually work and build up some pressure. It's now a real

flight suit in real vacuum. The suits that you train with get so much wear and tear that they're fairly flexible. They're still a lot of mass to move, but a Class 1 flight suit, the components in that suit have typically had so little wear to them that they're just intrinsically stiffer and less worn-in. We tended at least to be moving around the airlock quite a bit just getting a feel of “Okay, I've been in this suit before in at least two chamber runs, but now it's this suit in zero gravity. What I'm feeling is not the weight of lifting the suit arm and then the force of moving my elbow. It's now: what does it take to move my shoulder, what does it take to move my elbow. Just calibrating myself to this specific suit in the absence of net gravity.”

The really fabulous call is to finally get the go for final depress; you're actually going to take the cabin down to zero and then go for EVA. Fully pressurize the suit, enable the emergency oxygen pack. If the suit gets to that point and you're dumping the rest of the cabin, you've largely cleared any of the big hurdles. You now know the system is running stable; the fan's running good. At least to me all the sounds of the suit, they become background. Really quite analogous to how much attention do you pay to the sounds that your car makes as you drive down the freeway? None, except if something starts to clink, clang, or the tires start making a strange noise because one's going flat, you'll be keenly aware of the change. Until the change not it's in your consciousness at all. The suit, it's the same thing. It's just you know it so well, you know what it sounds like, you know what it's supposed to feel like. You can just focus on the task, and you're just living in the suit.

We scooted from there, following the choreography off to do our engineering tests. The ORS (Orbital Refueling System) engineering test was pretty simple and straightforward. It was out of the airlock, hook onto the tethers and the slide wires, stop by the toolkit. Dave was the prime guy on that job, so load on the little mini workstation tool carrier and the several different

tools that have been tailor-built for ORS. Then we trucked on back to that workstation, and he clamped himself in the foot restraint facing the device. My role, other than safety buddy, at that point was to position myself above the ORS device and back him up on procedures, as Jon was also doing. There were one or two points in that procedure, where you were removing fairly small components: peeling off some safety wire, taking off a small dust cap. The procedure called for being absolutely positive that you've got all the wire off, and you've got the dust cap out. There was always some prospect that your grip might slip a bit on a tool and you thought you'd pulled the dust cap out, but it was floating free somewhere.

The notable moment of the scouting role that I played was being an extra set of eyes in case Dave was focused on the tools and missed seeing one of these key bits float away. I think we took probably an hour and a half to an hour and forty-five minutes, something on that order I would say, maybe two, doing the ORS. It went pretty straightforward. We didn't have any of those little issues. What we basically were doing was connecting two fuel tanks, and the interface was a good model of a Landsat tank system.

The valve that Dave was peeling all the caps off of was fixed up just like a real Landsat satellite on the fill port where its tanks would have been fueled, and it was that kind of valve with just the same caps, closures, and safety wire that a Landsat would have. Then we had another tank that was a fuel supply tank. The task was to strip off all the covers on the Landsat side, put a protective housing around that valve, and then feed the fuel fill line down through that protective housing and open up a fuel path from the supply tank into the receiving tank. When you're all done with that, you've now got a pretty big chunk of metal, this housing and the fuel fill line, that are sticking off this little tiny valve stem that was never designed to support that kind of weight. You're going to bring this thing back home through all the dynamic loads of the

Space Shuttle reentering the atmosphere. The engineers recognized we need to brace this now almost foot-long gizmo that's coming out of this valve. We couldn't have it flapping around in the loads and maybe wrenching the valve off of the tank full of toxic propellant. That's a bad thing.

So we created a simple U-shaped bracket that was mounted onto the front face of the ORS and was made of two pieces. The two pieces had a hinge at the ORS, and they clamped together at what would be the bottom of the horseshoe. They would surround this big valve housing and support it during reentry. Dave's first job when we got out there was to undo the two halves of that clamp assembly and move it out of his way so he could get at the valve and start working on it. Well, that had always been a non-event in the water tank. You undo the fastener, you move these two clamshell sides away, and they stay there. You do your thing and then you move them back.

In zero gravity there was no friction on the hinges. Dave undid them and moved them back, but they're now just floating on the hinges. Any time his hand would brush one of the clamshell halves, it would propel it back against the back surface of ORS. It would bounce off of that. He had these two little clamshell halves flapping at his hand just the whole time through. They just almost never stopped, and they'd just be bam bam bam bam bam bam bam bam bam batting back and forth on his hand.

It was totally inconsequential, but it was quite amusing. It tickled us both, I think. We had worked really hard and brainstormed a ton together about what will be different in real-world zero gravity. We've done the EVA tasks in the water, and we've simulated the thermodynamics in software to be prepared for how this thing going to behave. But every model is an imperfect model. Every simulation is an imperfect simulation. In some way or another, the

simulation is lying to you, in the sense of patterning you to build a habit pattern or an expectation that won't prove right in the real world. On all of the crews I was on, this one in particular, we all really challenged each other on this point. It was almost a game. What won't be the same? What's not right about this in zero gravity? We've done that a lot, as good discipline and as a sport. Here was this trivial little parameter: "Oh that's right, there's no friction on the hinge." It never even entered our minds, and it was just this amusing little cartoonish moment. We chuckled about that.

Other than that, ORS went off really quite smoothly. We buttoned that up, and then the next thing was to come back forward in the payload bay. This was now the point Crippen assigned me to lead on the in-flight maintenance task, the EVA portion of it, for stowing the Ku-band antenna. I liked that. I was actually going to get to do something, not just watch things. That's always good. To get this done we needed to think a good bit about where our safety tethers and our slide wires routed to. We had arrived, in consultation with the ground, at the thought that since Dave's slide wire came off the starboard rail, best thing for him to do was go all the way to the forward bulkhead and over towards the starboard rail, but stop at a handrail that was above the Ku-band antenna. I was going to improvise a path across the front of the OSTA [Office of Space and Terrestrial Applications]-3 pallet that was about fifteen feet back I think from the forward bulkhead. Cross using the pallet, get to the starboard rail, and come forward in line with the Ku-band antenna.

Meanwhile Sally and company in the flight deck, and down below where the electronics that actually drive the antenna assembly are, would command the antenna boom to swing back inboard until it was aligned with the sill. That's its normal stow position. The problem was that the dish itself needs to be aligned along that same axis, and one of the motors that positions the

dish was what had failed. So my task, once Sally had driven the boom inboard, was to come up along the sill, gently grab hold of this fairly delicate carbon fiber antenna, and rotate it until these two triangular-shaped wedge-shaped pins could be driven into each other. It's very much like if you made the index and middle finger on both of your hands into a V and put them at 90 degrees from each other and crammed them together. It's just like that. Two V-shaped wedges locking together.

I started making my way across the pallet, and we wanted to do two other things at that point, one of which we had not told everybody on the ground about. One was the IMAX guys wanted some footage of the EVA. We had spent most of our time fifty feet back in a sixty-foot-long payload bay where we were itchy-bitsy figures that blended in against these big white chunks of experiment hardware. There was not a great scene. When we came forward towards the OSTA-3 pallet we realized this was going to be a much better time to take images of the spacewalk, because you could actually see that there were people out in the payload bay. Once we realized that I was going to do this improvised path across the middle of the bay, that was going to make a cool moment. We paused for a couple minutes at that point, right about when I was halfway across the pallet. It was a great scene. We had Venezuela going by underneath us and a nice landscape. Jon wrangled the camera up to the window and got a bit of film. Then he dove down below to get back into the in-flight maintenance task.

The other thing we wanted to do, I think we did when this was all done, came out of something we had realized that when we watched the rough IMAX footage that the [STS]-41D crew had shot. They took a pretty cool view where they put the camera right down on the flight deck floor just behind the C3 panel looking up, basically towards the vertex between the overhead and the aft wall of the flight deck. You saw the two aft-looking windows and the two

overhead windows. Since cameras don't show you stereoscopic view, it looked like those were just four windows on the same surface. You really couldn't tell that two were vertical and two were horizontal. They shot a scene where you just saw the Earth scrolling by through this four-paned window. We watched that rough bit of footage during our IMAX training, and instantly, I think this went through Sally, Jon, me, and Dave and maybe even Crip simultaneously. We realized "Cool scene. Ooh, and we could shoot that with faces in the window!" We wanted to do a "Kilroy is here" scene. We'd have that same scene and then have Dave and I rise up from the bottom of the windows and wave inside. That was going to be our last gig on the EVA.

We finished the first IMAX scene. I got across to the sill, and I was pretty confident we had deciphered everything and that I had a good sense from the teleprinter cartoon efforts of what is this detailed bit of hardware on the Ku-band that I'm looking for. Happily it was very vividly apparent once I got there. It was just as I had understood, which was sure a comfort. Then we just had to choreograph and coordinate between each other. Are we in position? Are we ready to go? Crippen probably yelling to down below, "Okay short the circuit. Drive the pins!" It worked fine. Interestingly, that exact same repair and exact same EVA ended up repeated years and years later by Kathy [Kathryn C.] Thornton on another Shuttle flight. The same Ku-band failure, and the ground guys said, "Wait, we have this procedure. Guess what? Another woman named Kathryn, spelling it the same way, did this before."

We finished that up and, as I alluded to, we had not told the IMAX guys about the Kilroy scene. IMAX budgeted some chunks of film for just crew discretion, and we had not told them about our vision of this great scene where we two rise up from the window. We did that, I don't remember where we were in terms of TDRS [Tracking and Data Relay Satellite] coverage. It may have been that we were out of signal range. We had pretty well thought this through and

choreographed it well enough to be able to do it on coded cues amongst ourselves so no one would really quite figure out what we were doing. We did that. That was just hilariously fun, Dave and I floating up at the same time, looking in. When I watch that scene—it's a great scene in *The Dream is Alive*—it always tickles me to see both of those scenes. I notice that Dave looks in the window, and he's just waving all the time looking at the camera. I look in the window. I wave a little bit. Then I'm right away looking at the Earth going by, because we didn't really have that much time to just take in scenery, and that was pretty special. Waved to the camera once, and then I want to see some more of this, so I'm off looking out and down towards the Earth.

So then it was pretty well button things up. Our sequence was I'd go by the toolkit that's embedded in the bottom of the payload bay, put my gear in first, and then go into the airlock. Dave would come in after that. That mainly went fine, with one little detail that became one of the amusing points of our EVA. Those airlock depress valves I was talking about? The cover for the valve that passes between the airlock and the outside world is embedded in the hatch, the hatch that's open and is now lying flat in the airlock. It's the floor of the airlock once you've opened it and locked it in its open position. The hatch has stiffeners that are I-shaped ribs that stand up about four inches off of it. At the time, the airlock depress valve had a little piece of Velcro on the top and was parked on patch of Velcro that was on the top of one of those ribs. Well, as I shoved my feet in and twisted myself up to get up into the top of the airlock, my boot scuffed that. It had this teeny-tiny little wire tether that held it there, and my boot popped the tether off. As I'm working to get myself in, I see this thing go floating out above me and just fast enough that by the time it computed what it was, it was past my reach.

A few feet away, Dave saw it and recognized what it was. He went after it. Crip's trying to figure out for a moment what's going on. Says, "Dave, just let it go." Dave cryptically says, "No, Crip, I don't think this is something we want to let go." He makes his way up across the OSTA-3 pallet up onto the radar and manages to grab it as it's going by. As he manages to grab it, he loses his grip with his other hand so his safety tether reels him in to the forward bulkhead like someone being reeled in on a line. Pinky [George D.] Nelson was our CapCom [Capsule Communicator] down on the ground. I remember Pinky saying something like, "Oh, I think you get a ten for gymnastics." So that was our little bit of comic amusement getting into the airlock. From that flight onward the depress valve cover was put on a piece of Velcro that was protected by the ribs instead of sitting out on top of the ribs. How did we get through five EVAs and not figure that one out?

Before long we're back in, popping out of the suits, and everyone's happy. Everything's done. We got the IMAX. We got the antenna done. We were back. Everyone's celebrating. I don't think it matters how big or little the EVA was. It's just you actually got to do this. It's amazing. It is just a really fabulously cool experience. I would love to have done more, but only a small number of folks ever get to fly in space in the era of history that we've come along in, and only about a quarter or so of those ever get to sneak outside. I'm not going to diminish one dose of sneaking outside just because I didn't get two, three, or four. It was fabulous.

ROSS-NAZZAL: I have to ask you a question that I think is goofy, but one of our interns pulled this together, and they mentioned that the Soviets fired a warning shot at your crew from Terra- [3 laser complex at Sary Shagan]. Do you remember that? You know how you see things on the Internet and people pull things off the Internet? I'm just curious.

SULLIVAN: I have no recollection.

ROSS-NAZZAL: I didn't think that was the case, but I thought it'd be nice to put that on the record, so if anyone's out there looking at this kind of information, thinking, "Oh Soviets had done this." Like UFOs, people search for that kind of stuff.

SULLIVAN: No, I don't recall any such thing. It was not any kind of thing we talked about in the crew, and certainly not like a ballistic space weapon. I have no recollection of it, not in prebriefs, not in flight notes, not in message traffic, not in onboard conversation, not in anything, nor any awareness of some side channel conversation. Did Crippen know something that I didn't know? Crip knows lots of things. That flight in particular Crip knew lots of things I didn't know yet, but I didn't have any sense of any kind of jeopardy to crew or threat to vehicle or anything like that that was present. So no.

ROSS-NAZZAL: I thought it was bogus, but I thought I'd just ask if that was indeed the case.

SULLIVAN: No. Now we were only the second high inclination Shuttle flight. The first one was Spacelab 1. That was a two-shift crew with people working back in the Spacelab module where there are mainly no windows. The flight deck guys had a lot of time to look at the Earth and take pictures while they were standing watch on the flight deck, and John [W.] Young shot scads and scads of pictures, and some of those pictures did create some controversy. He got a spectacular shot, frankly, of a portion of the Kamchatka Peninsula that just, oh, by the way, happened to

include the Pacific fleet base at Petropavlovsk and some other interior Soviet Union sites that maybe were around some of their missile launch sites. I think there'd been some official diplomatic protests. The Petropavlovsk shot ended up on the cover of *Aviation Week*. It was always reported or rumored that 300 and some copies of *Av Week* went straight off the printing presses directly into the diplomatic pouch and over to Moscow. So who knows?

I suppose it's conceivable at some State Department or diplomatic level there was some further teeth-gnashing about a high inclination crew and violating our territory. We were given a briefing on, "These are sensitive areas of the Soviet Union, and we don't need photos coming back of those, ladies and gentlemen." It certainly seemed that there had been some diplomatic reason that trickled down to us in guidance to "don't be taking pictures of places that are going to cause further diplomatic problems." We are not a military agency. There's not a military purpose to this. There is not an intelligence-gathering purpose.

ROSS-NAZZAL: President [Ronald] Reagan called when you were flying your first flight. What are your recollections of that?

SULLIVAN: Oh, they should be vivid. It's not a small deal to talk to the president of the United States in any way, shape or form. But for me at least, it's a short couple-minute press conference in this swirl of events that's just mesmerizing and all-absorbing, and so I have to be reminded that that happened. If you just sit me down to list out the vivid memories and impressions of especially my first flight, it absolutely centers on the Earth view. Everything about the amazement of actually being there, actually doing these things, actually seeing these sights, and how astonishing it all was that this young little girl, a Cessna pilot from southern California, can

end up in this place. It seems so understandable, normal, and natural to be there, and day by day as you go through the first flight your comfort, your groove, and your pattern with working in the vehicle expand. For me part of what was happening was just learning like crazy, drinking from that fire hose for all those months of getting ready.

On a first flight flow, I have no reference points. I'm not confident that I know how to judge, "is this how much I should know at this point? Is this how adroit I should be with this procedure at this point? Is this how fluid in the suit I should be at this point? Am I on speed? Am I ahead? Am I behind? Where is this? How do I scale this?" I always respected the folks who were training me, they were good, competent folks. They seemed to know their stuff, and I considered them partners in making sure that we were really ready to go as a crew, and I was ready to go in my role. We had a very open exchange, "Tell me what you're thinking about. Tell me what you're worrying about. Tell me what you're wondering, just talk to me." This is a partnership to be sure nothing is left untapped, nothing is left unpolished, and it's as good as we can get it. So I had that.

So it was exciting to actually get in flight and be able to confirm, to calibrate, to measure, how my training mapped into performance. That was growing with every single day, and it was very interesting on my second and third flights to just see how the cumulative experience sharpened my focus. You're focusing in on finer and finer scale things as you get further in the experience curve. All of those experiential pieces, they are what stands out. The camaraderie, the fun, and the things we did as a crew, that all stands out. I was a coinvestigator on some of the imaging radar experiments, so really was immersed in that. In all of that any particular ground conversation, sorry Mr. President, is a little lost in a blur. Now, the state dinner that I was invited to at the White House a month or so later, where I sat at the president's

table and immediately next to him at his left hand is very, very memorable. But do I remember the three-minute phone call from the president of the United States? To be honest, no.

ROSS-NAZZAL: We did talk last time about your work with the people at JPL [Jet Propulsion Laboratory, Pasadena, California]. Do you want to talk about your work on the experiments on board the Shuttle?

SULLIVAN: Yes, it was interesting, because one of the roles in the astronaut corps was what we called mission development. In this job, an astronaut becomes crew technical consultant to a cargo before an actual crew is assigned. Our cargo, the refueling system, the Earth Radiation Budget [ERB] Satellite, and the OSTA-3 pallet, had had such liaison as it was being developed, and I was in that role for some number of months, I want to say something between six and twelve months, before the rest of the crew got assigned. I had an overview of the cargo.

Once the crew is named, though, Crip's has three mission specialists, and the strategy is to make someone the primary crew member on each of those major components, and then mix and match so everyone's got a backup. Then you've got to think through things like: who has to train as flight engineer, because they're often going to be off with the pilot and commander; who has to train for spacewalks, because they're going to be underwater, and really helps the training schedulers if those two assignments don't include the same person. You can put two people underwater and three people in a launch or landing sim [simulation] and get big chunks of training done simultaneously. Crippen had to manage all those variables and decide our lineup. He can tell you all the detailed reasons, but I would imagine the thinking was the OSTA-3 pallet is predominantly Earth sciences and Sullivan's a PhD Earth scientist. In fact I'd been out in the

field with them. I'd been deeply immersed in setting up their observing plans and really digging in to know each of the investigators and what their scientific objectives were, with the intention of being able to really, really act as a very richly-informed proxy for them in terms of onboard decision-making and any improvising that we might have to do if things went wrong and if we didn't have perfect communications.

There was also a little tension around that payload at the time, and between JSC and JPL, with JPL arguing that this was such a complex set of experiments and such a diverse array of scientific objectives that no mere mission specialist who works with it all for maybe a year or so could possibly come up to speed well enough to fully and properly represent these scientists on orbit. Therefore, one of the science team should go as a payload specialist and operate the cargo. This is early Shuttle Program days, and there's still a lot of jockeying around what are the parameters that define the role of the mission specialist versus the role of the payload specialist. How often do you want payload specialists flying? There was lots of interplay at [NASA] Headquarters [Washington, DC], at JSC, at the other Centers. This issue on our crew was just caught up in that whirlwind.

The local JSC politics certainly were that it was important to make a demonstration case that the scientists who have become mission specialists are very well-credentialed, intelligent, smart scientists who are more than able to be proxies for science teams in very complex circumstances. JSC was trying to hold that line, and JPL was trying to argue, "One of our guys has to go." All of that together surely played a big role in Crip's decision that I should be assigned as the lead on OSTA-3. That was my lead.

Sally was already a skilled RMS [Remote Manipulator System] operator, and the ERB satellite is an RMS deploy, so she's going to do that. That leaves the refueling experiment for

Dave to be lead on. Dave backed up Sally on the arm, and Jon also had to back Sally up on the arm, because there was always some possibility Dave would be out in the payload bay when some arm task had to happen. Crippen, like any good commander, could back up any of us on anything. That's how he cross-strapped us at any rate. It was me backing up Dave and doing the EVA with him on the ORS, Dave backing up me on OSTA-3, and that was our lash-up.

In terms of the OSTA-3 experience, I think we talked last time about the one notable occasion where that really paid dividends in terms of the optical recorder overheating. Our having set our crew up so that I could put that kind of detailed attention into really understanding what actually are the hardware constraints here you're worried about protecting? Why is this software limit set at this temperature instead of another temperature? What are the real no-kidding factors that could go big bad wrong here? What of the rest is judgment or maneuvering latitude? We got that right and came to a clear understanding, and used that one evening to very good advantage to save some of their data takes.

ROSS-NAZZAL: What did you learn from your flight as a coinvestigator?

SULLIVAN: That was a great in-depth exposure to radar remote sensing, and it came back around in a number of other pathways later in my career when I got involved in Navy oceanography. These were very early experiments in the early- to mid-80s, the fruits of which come down into things like our ability nowadays to measure sea surface heights, the shape of the geoid, wind speed and direction with radar altimeters. That all boils down to the detailed understanding of how electromagnetic radiation in the microwave wavelengths interacts with the fine scale surface roughness of the sea. What sort of scattering characteristics do you get?

Many of the early Shuttle Imaging Radar investigations were still looking at those detailed radar backscatter mechanisms and trying to develop or confirm the algorithms that would let you later develop an operational radar satellite. You need enough data to be confident, when it goes over Arctic regions and sends back data that you process with this algorithm, that you can tell whether you're seeing first year sea ice, multiyear sea ice, other features that would matter to you if you're, say, the Joint NOAA [National Oceanic and Atmospheric Administration]/Navy Ice Center [Suitland, Maryland]. Those were the kinds of things that people were doing; it was that level of investigation.

The guys I was working with were Jim [James W.] Head [III] and his folks up in the Earth and Planetary Sciences Department at Brown University [Providence, Rhode Island]. Jim's primary interests were with radar satellite imagery that had come back from Venus. He was using SIR [Shuttle Imaging Radar]-B to look at Earth terrains that one imagined might be broadly similar to some of the landscapes on Venus. So, in the Earth case I can know what the geology is, I can go out into the field and measure cobble size, boulder size, sand size. Then I can take radar measurements and confirm yea verily I see this kind of scattering behavior from these materials and this other signature from those materials. I can then use that positively-controlled knowledge to sharpen my inferences when I see a radar image back from Venus. You're not going to get there and pick up samples. You had the very brief windows of data returning from the Venera spacecraft before it turns to toast in the harsh conditions on Venus. You've got tiny little glimpses that maybe give you a sense of the actual geological materials there, so it made sense to develop signatures based on well-controlled Earth experience that could help to bound your interpretations. That's what we were doing.

ROSS-NAZZAL: What are your memories of landing for this flight?

SULLIVAN: Dave and I were the swappable crew members. Sally was third seat flight engineer, and so Dave and I got to flip a coin over who sat on the flight deck and who was down below for launch and landing. It was amicable and simple. Dave and I always enjoyed each other's company, got along well. One way or the other, we split out who rides where for which phase of flight. I took flight deck for liftoff and that put me on the middeck for reentry.

Entry day, it's another complex evolution. You know those joke cans that you see slapstick comics play with, where they open the can and a huge bunch of spring-loaded worms hop out? Getting into orbit and shifting the Orbiter from stowed up for launch configuration into living in orbit for a week always reminded me of all those worms springing out of the can. An incredible amount of gear and stuff is stowed away into all the lockers. By a day or two later you've got stuff deployed and Velcroed everywhere, sleeping bags here, and food containers around there. Of course, we had a stowage and a deployment plan, so very little of it was random. It could be random where you had parked your orange juice container for the moment, but beyond that not much was really very random. You knew where things were going to be.

It's this incredible clutter compared to how buttoned up it all was when you climbed aboard on launch day. Needless to say, reentry day and/or deorbit prep, it's the reverse. The giant sucking sound you hear is all that stuff going back into its stowage locations, with the exception of big laundry-type bags that carried spent film, the shot film, in one bag, so it could be grabbed off quickly, started into processing. Dirty laundry went into one or more bags, which by the time a crew of seven is ready to come home after seven or eight days looked like the bag that ate Chicago, just huge. These things are just lolling off at the end of their tethers or jammed

up into the airlock somewhere. You start to feel you're on the downhill during the whole deorbit prep evolution, which is a goodly number of hours. Kind of like on vacation, when your sense shifts into "going back" mode. There's just a background awareness as you get towards the next to next, next to last, and last day before coming home of "this is the last time we're going to use this." So you unpop everything all at once on your first day in orbit, and things start rolling themselves back into order for about a day and a half before you come home. Then there's a very focused period of deorbit prep where you're really configuring the vehicle for re-entry.

It's neat choreography. Growing up on family vacations, everyone would dump all the stuff that needed to get in the little luggage compartment of our airplane out on the ramp, because I was always the one that could stow it best. I picked up my fourteen-year-old habits and just loved the fact that look, "I've been stowing airplanes since I was thirteen, and now I'm stowing spaceships." This just was fun. It was just one of those little personal notes of amusement.

We'd gone through deorbit prep several times in training, of course. I think we were already pretty smooth at how our deorbit prep was going to go before Marc Garneau and Paul [D.] Scully-Power were added to the crew. As we deployed ourselves for deorbit day, my job was basically going to be stow up the middeck. Get everybody ready. We were not returning in heavy pressure suits back then, so we didn't have to cycle people through the middeck for and help with the suit-up, as you tend to do nowadays with the launch and entry suits. The split was Jon and Crip of course had to get the vehicle configured from orbit mode to deorbit prep. Sally was going to be in the middle of that, helping with those procedures and crew resource management. I was definitely going to be middeck, and Dave was a flex player.

It was good to have Dave's help to bolt the seats back down. We'd stowed them away, and now had to rerun the oxygen lines and just get everything rerigged. Button everything up. Also, on all three of my crews, we'd take out washcloths the night before reentry. Little bits of juice and things have always gotten away through the course of the flight, and there's spots, stains, and dirt smudges around the vehicle. It's just a show mutual respect to the ground ops [operations] crew that gave you a good vehicle, clean and sharp in good working condition for you to take off in, to bring it back nice and clean. You don't bring home a dirty spacecraft. It's tacky. They did better for you, you do better for them. We'd go wipe down the whole vehicle and clean up the worst bits of it and get everything pretty buttoned up.

That's what I'm mainly mindful of. I was just focused on doing the whole middeck stow. Dave was helping me with seats. I don't have real clear awareness of where Marc spent a lot of that day. I have the sense he was up topside, because his stuff was now finally stowed. I think deorbit day was probably one of the few chunks of time that he actually got to enjoy a decent interval looking out the window himself, because so much of his work kept him down below. Paul was down in the middeck, I remember, having his last good time with zero gravity gymnastics. I was not amused at the time because he was having a ball hovering himself out in the middle of the middeck and doing flips and tumbles, which is terribly fun to do, but he was right in the middle of everywhere I needed to be. He seemed totally unaware of the fact that there actually were things to do that day. "Hey buddy, there are actually some important things to do today, and you're in the middle of the pathway."

I remember very vividly the moment that Crip switched the autopilot from the fine scale vernier control jets to using the primary control jets and to using the thruster pod that's up in the nose. To create a smooth and quiet ride and be able to sleep, the Shuttle commonly stays on the

vernier thrusters, and even if you're not using verniers you tend to use tail-only RCS [Reaction Control System] jets. The 870-pound thrusters up in the nose pod, when they fire, you feel like you are living in a dumpster and someone just whacked it with the world's biggest sledgehammer. The whole vehicle seems to resonate, it's a big metallic thunk, and everything seems to resonate for a while. I could tell instantly when—well, I couldn't tell when Crip hit the button to switch it over to forward primary jets—but I could tell you instantly when we hit a dead band that needed a forward jet, because as soon as that jet fired Paul went rigid in the middle of middeck, and his eyes were eighteen inches diameter. He thought the vehicle was coming apart, and he shouted out, said, “What the hell was that?”

It was probably between clenched teeth that I said something like, “It's a primary thruster, Paul. We're going home today.” We got everybody squared away down below finally and seats buttoned back down. Crip had said that once I got the middeck all stowed and buttoned up and our two PSs [payload specialists] properly configured, I could come back up on the flight deck and stay up topside for the burn for and a bit of early re-entry. Watching the OMS [Orbital Maneuvering System] burn was going to be pretty cool. I did that.

I remember we had a last pass over Nova Scotia. I was looking out over Jon McBride's shoulder, pointing out where I went to graduate school. After that we did the burn, and we're starting on our way home. I floated on back down and buckled on in. If I craned my neck back, I could just get little glimpses out through the portside hatch window when we were in left banks. There's not much there for some of reentry. You can see some of the plasma sheath as you go through the peak entry heating regime, and then as we came down over the southeastern United States, our corridor took us right over the Ouachita Mountains, over a few of the Tennessee Valley Authority reservoirs, and then on into Florida.

I remember one of our big banks to the left, I was looking down at some of the big old reservoirs, don't ask me which one it was, but one of those Tennessee/upper-Alabama area of lakes. Back to the right again and back to the left again, when I could see just a little bit of the Florida shoreline, and then we're turning in and landing. It's remarkably smooth. Everyone's teasing about "is the laundry bag still floating?" When the laundry bag hits the floor, you're definitely near home. "What's the G level?" It was fun being on the middeck. You can't really follow entry events in detail, so you can focus on the sounds and sensations. You're beginning to feel different sensations on your body than you've felt for the last seven days, and everyone has a natural curiosities, "Ooh, what's this G level? How big is this one?" You haven't felt anything heavy in so long. Crip would call out G levels now and then, velocities now and then. It's an amazingly smooth ride. At something around Mach 12 there's this little brief bit of, it's almost high frequency chatter. It reminded me of if you went over four or five sets of railroad tracks at a very smooth level crossing, but you'd still have a little trum trum as your tires went across the tracks. It was just like that, gone quickly, didn't destabilize the vehicle, just a little chatter. Then a good bit after that, the wind noise starts to build up and you start seeing things sag towards the floor. The books are hanging on their tethers. It's feeling harder to lift your arm.

Both my other flights I chose to launch on the middeck because I wanted to just be able to absorb all the sights and sounds of launch without being absorbed in checklists and procedures. I would launch on the middeck and come home on the flight deck to get that grand view. On the third flight I remember very much that the first physical sensation I had as we decelerated was of my eyeballs pressing gently against the inside of the eye socket. The Shuttle's going slower, and your seat is bolted to that. The straps are attached to the seat, the straps are pulling your skeleton back, but all the soft bits of your body are only going to slow down when

they're restrained by the skeleton. Just being aware of a little bit of eye bulge feel, which I utterly didn't detect on the first one. So that was that, and then we were back in Florida.

ROSS-NAZZAL: Was your family there to greet you?

SULLIVAN: No, they were in Houston, because among NASA's many little rules are some that define who constitutes family. The definition has tended to be spouse or maybe spouse and kids. For single folks, at least at the time, they didn't regard parents or brothers as family. It's spouse and kids if you're married, and no substitutes if you're single. I felt it was a rather idiotic approach, but that was how they did it. So my family was waiting back in Houston.

ROSS-NAZZAL: You returned that same day to Houston?

SULLIVAN: Yes. It takes about forty-five minutes for the ground guys to sure the vehicle is safe, clear everything, bring the gear up, and open the hatch. This was in the go-down-the-stairs day, not in the crew transfer vehicle day. So we went down the stairs and walked around the vehicle a little bit. Still striking me as we were walking around in the middeck before they even opened the hatch, I was thinking, "Thirty minutes ago I was floating right up there." It's just quite amazing, where you've been, and where you've come from just sticks with you. A bigger version of that experience we all know, the day you're back from vacation and you keep referencing, "Gosh, yesterday I was on the beach in the Caribbean," or, "Gosh, yesterday I was underwater with whale sharks," and we do that. It's part of how we process when we've had amazing experiences. These are that plus-plus, but it's the same natural habit pattern.

So we got done; we got off the vehicle, and they schlep you back to the crew quarters. The docs [doctors] get a first look at you, of course. Go through that stuff, whatever vital signs and blood draw and stuff they want to do. It's hard to be patient, because you just want to get back to friends and family. I think Crip, Sally, Dave, and Jon had spouses there; I think Paul had spouses and some of his kids there, I think. I think Marc maybe did too. At any rate the big thing was getting quickly away from the docs so we could hit the showers. The first flowing warm water shower just felt fabulous. That was great.

Then we just hung out in the conference room telling stories and reliving the flight. I can't imagine what it's like to be family and come there and hear this babble that's just so intense, so vivid and so real, and probably in some ways cryptic. Just laced with all the little insider detail, because now you're using all those accelerator hints, winks, nods, and code words that come from the tiny little fine scale of events that happened in flight. You haven't had any chance yet to really process it, much less convey it to anybody else. It's an interesting experience, on either side of that experience it's an interesting thing to be a part of. Then we finally boarded the airplanes.

We did all get back to Houston. When the Gulfstream-1s got back, a tremendous rainstorm had settled over the airfield, and so they actually taxied the G-1s into the hangar. A number of us had lingered around. Sally and I had lingered around to greet Marc, welcome him back to Houston, shake hands and say see you tomorrow, see you in debriefs kind of thing. His plane pulled into the hangar, and they closed the door. Sally and I came out from the office area of the hangar out onto the hangar floor. There was just a sea of people crowded up around that airplane. Marc and his wife and their kids had made it down the stairway and were now almost

trapped in the angle between the air stairs and the airplane fuselage with this press of media folks pressing in on them.

Sally and I stood there looking at this for a while and then we looked at each other and said, "So let me get this." We joked that here we were, the first American woman in space, first American woman to fly twice, first American woman to walk in space, and a sea of media who appeared to not care. We said, "Yes, that's right. Good, we're out of here!" Waved at him and left. See him tomorrow.

ROSS-NAZZAL: I did want to ask you about your PR [Public Relations] trips, going back to the hometown and then you mentioned the state dinner. I was wondering if you could elaborate on those.

SULLIVAN: Yes, I especially have always liked talking to educational audiences. It's not a huge hardship to go tell such great stories, relate such fabulous experiences, to the people who paid for it. If you take the whole national service thing seriously, at some level, these ought to be the people that you're aware of having done it for. You get a lot of benefits out of it on a personal level too, but we didn't actually create the space program for Kathy Sullivan to go have rides. That was pretty fun, and I had, like we all do, thought about institutions that I cared about that had shaped me a lot and offered to take things aloft for them.

One of my guidance counselors and my French teacher from high school were still both at the high school, and they were both—my French teacher in particular—really influential people in my life. I'd been in contact with them and had a small school emblem that I got mounted up with a California flag and some pictures. Go out to your old high school on the

football field and have this big assembly, and say to all the students, “Yes, it's possible to get from this little place in southern California all the way up there.” One or two of my classmates came by, and we kept in touch as we all went our slightly different ways in college, but that was also fun to link back up with people. I had one gal in particular I'd known since second grade. We'd been close friends since sixth grade. Fun to have her come back and be part of that whole celebration.

I went to the University of Bergen in Norway for my junior year at university, and that was a fabulous experience. I still love to go back to Norway and have friends there still that I catch up with episodically. I'd been in touch with the university and offered to take something aloft. Bergen has a very long history back to Celtic and Viking times. Some years before our flight they had done a new round of archeological excavations on the north shore of the inner harbor and had gotten back to around 1,000 AD or thereabouts, when it was still a pretty significant shipping harbor in the era of Viking ships with the big carved high prows.

One of the artifacts they had found was a piece of wood about fifteen inches long, would have been a tree branch—maybe two or so inches in diameter. Part of it still has a rounded back to it, and one face of it in particular has been shaped to fairly flat. All of it's been shaped a bit. This appears to have been an accounting ledger, because the flattened face has etchings on it. You can count a number of prows of ships, and you can see clearly by the styling of them an indication of several different classes of vessels. Artistic perspective didn't exist when this was carved, it's a flattened view. On the rounded parts of the shaft there are other caricatures, other runic figures. Near as I can tell this was someone taking stock of what vessels were in port, and some notes about presumably their cargo. So they asked if I would fly that runestokk in orbit.

Well there's normally a complete prohibition against burnable objects in the spacecraft, but somehow NASA saw its way to make an exception for this. It was all bundled up in plastic and stowed away with the official flight kit, but it went to orbit. So one of my really, really fun postflight visits was back over to Norway. It really was a standout trip. The American embassy in Oslo, US Information Agency, and the university are all colluding on the itinerary. SAS [Scandinavian Airlines] jumps in and provides me first-class air travel across the ocean. There was a dinner at the ambassador's residence. I invited both of the gals who had been on contract as our foreign language teachers for the first summer, but only one of them could come, and a family whose farm we had lived and worked on as part of our language training, they came.

Then I went out to Bergen and gave some presentations, and presented the runestokk back to them. I'm fluent in Norwegian. So another delight was to be able to show back up—twelve years after I was an exchange student—still speaking in Norwegian and addressing the student body and the university officials. One of my classmates from California during that exchange year had married a Swede and was still living in Bergen. Another part that was fun was to have this gal come out to the university hosted dinner at Bergen up at the Floyen Restaurant. A thousand things were fun about that.

It also was my first trip across the Atlantic since when I last had flown across the Atlantic in a Space Shuttle. I get to JFK [John F. Kennedy International Airport, New York, New York] and checked in and went up in the front of this 747. The crew obviously has been told my story, so there's all this fun “ooh and ah” going on. I settled into my seat to go to sleep across the Atlantic. So I put on my little booties, my Walkman, the little eyeshades, and push the seat back. I had still some of the cassette tapes of music that I'd had with me on orbit and was playing that in the Walkman. I've laid back and I'm settling on in, when I jolt suddenly upright and realize,

“Oh my God the last time I had a Walkman and eyeshades on I was sleeping on a Space Shuttle and was across the Atlantic in a heartbeat!” I flipped the shades up. We'd already been flying quite some time as far as I was concerned, but I flip up the shades and discover that we have not even passed the eastern tip of Long Island. I was stunned. In the time we'd been aloft, we'd have been nearly the way around the planet in the Shuttle! Put the shade back down, said “this is going to be a long flight,” just went back to sleep. That was fun.

I did my exchange year in Norway on less than a shoestring budget. Soon after we arrived there, President [Richard M.] Nixon untied us from the gold standard, so everyone who hadn't changed over to kroner found their bank account cut by about a third. In my case, this was the bank account for the whole year. So I was living the life of a very scruffy student, getting by on nickels and dimes. Now I was coming back, but in such a different capacity. Being put up at the fine hotels that we used to slink past because we'd probably have been thrown out of. Not thinking a bit about dining at the Theater Cafe on Karl Johann in Oslo. The restaurant we had our big dinner at in Bergen was the very fancy restaurant at the top of the funicular railroad. We would ride the funicular railroad a fair amount, but it was in our hiking gear to get to the top of the mountain plateau and spend the Sunday hiking up on the mountain plateau. The charge for the funicular was high enough. You were going to walk the whole plateau so that you could walk back down to your dorm. It was just really hilarious to come back in all these very different ways.

I had a bit of time off when I got to Bergen, so I put on my scruffies and went up the funicular and decided to hike the plateau again the whole way around, back to near where my dorm was, and then take the bus back into town. It was a great day; it was pretty decent weather. It had been rainy—it's always rainy in Bergen, so the plateau surface is always soggy and wet.

There are plenty of sheep. I was just scruffing along in running shoes. It's not that hard of a walk. By the time I got back to in front of the hotel in Bergen, which was the Grand Hotel downtown, again, not anywhere I could ever have gone as a student. My shoes were sopping squishy wet, and they smelled like sheep poo, because I've basically been tromping through eau de sheep all the way around that plateau. I realized this as I hopped off the bus and knew I couldn't just sashay across the Grand lobby like that, so I took my shoes off in the vestibule and pitched them in the garbage before I went inside. All those things were quite fun.

The other thing was at some point during our EVA I had a moment to look down, and we were crossing Long Island. It was a really clear day. You could see Cape Cod [Massachusetts] off in the distance, and I was always peering off to see if I could see a bit of Nova Scotia. I was always looking at that East Coast corner a lot. I just looked down and happened to spot that it was Long Island, and a favorite aunt and uncle and some cousins live there. I just spontaneously blurted out, "Hey, there's Long Island! A lot of Sullivans live down there." I figured it would be fun to get that little clipping and play it for my uncle the fighter pilot at some point. Well, that created quite the buzz on Long Island, and I was swamped with appearance requests. Maybe I said something in that same sentence about "and Cape Cod," because Barnstable, Massachusetts also just had to have me come up there. You learn your lesson about "be careful where you mention," because one way or another you're going to go out there and talk and do days and days of public relations if you do.

The Barnstable trip ended up being additionally funny because Fred [Frederick D.] Gregory had been scheduled to do an appearance in Newburgh, New York, around Stewart Air Force Base at the time. Something came up. He had to cancel it, and so the agency was trying to provide them an alternative astronaut for a big day's worth of school events and civic events. I

was at least going to be out on the road doing PR and up in the same neck of the woods. The problem was neither Barnstable, Massachusetts, nor Stewart, New York, is exactly the center of the universe. The Barnstable guys, they had their day all scheduled, and it was going to run till 8:00 or 9:00. It was running through a dinner that was going to go for who knows how long. The Stewart guys wanted their day starting at 0-dark-30 the next morning. We basically put it on the back of the folks at Newburgh and said, "I'm obligated here till at least this point." I think I talked to the Barnstable guys and bought back an hour or so, "Can I show up for the front of this dinner and maybe not stay the whole time?"

"That would be fine." So this is the earliest possible time I am loose at Barnstable, and if you can fix your start time and solve the challenge of how to get from point A to point B, fine. They chartered a plane and they flew over to Barnstable. I'm figuring they're going to charter a plane to come fetch me, and I'll get a little bit of downtime and recompose, because it's going to be another wall-to-wall day the next day. Not quite. They loaded the three most avid space fans into that airplane, who were going to have their chance to talk with me all the way back, a captive audience. I'd just finished a fourteen-hour day, total wall-to-wall people, and now I'm crammed in this little tiny tube with three completely avid space fans.

We get back to Newburgh, and the place they've put me up is this very nice condo, not a motel room, with a large split-level space. They escort me up to the door, and they flood right on in. It's pretty clear they think there's plenty more time we can party. That's when I put my foot down and said, "You guys can party anywhere you want. Not here. I'm going to bed."

So the Newburgh day, it really did start at 6:30 in the morning and went forever. It opened with a big civic event out on a draped platform, proclamations, all that kind of stuff. Well, the platform was draped, "Kathy Sullivan Day, Newburgh, New York." All the

proclamations are proclaiming “Kathy Sullivan Day,” keys to the city, this, that, the other. Of course I know that up until about thirty-six hours ago that was all going to read “Fred Gregory Day.” We understand what's really going on here. I'm quite pleased to fill the role, but don't be too fooled into thinking it's really “Kathy Sullivan Day.” It's “any breathing astronaut day” to amp the excitement. All to a very good end, though—to encourage and inspire the teachers and the students. It's all good things, but it just was one of those very vivid moments of if you ever had the inclination to make the mistake of believing that this is genuinely acclaim for you personally, you just about hear the rip as they ripped down the Fred Gregory stuff and reprinted the Kathy Sullivan stuff. Yes, I think any two-footed breathing astronaut will do just fine. That was a pretty funny day.

ROSS-NAZZAL: Did you keep any of those mementos? Or are those just things that you just have so many of that you just keep select ones?

SULLIVAN: I doubt that I have all of them, but there's closets full. Yes there's closets full and closets full. You could keep all of them, I guess, but why?

ROSS-NAZZAL: You've moved several times since then.

SULLIVAN: Yes, I'm a vagabond, and not a pack rat. I have never passed the pack rat test. I go through and triage things periodically. My brother is the pack rat, and the one time they were needing to figure out how to lighten the load and move house I said, “You guys go to Mammoth

[Mountain, California] for three days and let me loose. I'll have your garage completely solved.” He was terrified to do that, because I would just go through things that just will make him crazy.

Not very long after we landed from 41G I found myself directed to go up to Washington. Of course what I wanted to do was be directed to get back in the flight queue and get a flight assignment right away. The post-flight celebrations are great, but really back in line to do this again is where you want to be. Marc Garneau is now the Alan [B.] Shepard [Jr.] of Canada. He's going to be eating chicken dinners for years. All this press and stuff Sally had to go through, and all the stuff Marc was going to go through, I had this nice little bit of accomplishment and notoriety, a fabulous experience, and just low enough a profile to not be a huge deal to any of the PR machines that matter. So can I just go back and fly again, please? It didn't work quite that way.

Somewhere along the way the president had decided to establish a commission looking at the future of the civil space program, the National Commission on Space. It probably had been decided that at least a current astronaut needed to be on it. Somewhere along the way it had been decided that was going to be me. So I was sent to Washington and was visiting around with different people. I do remember indulging myself at least for half a day or so in the thought that it was still up for discussion whether it was my assignment. I certainly tried to argue that there were much better people than me to do this, so that I could sneak back in line and go fly again.

I really didn't get too far with that argument. It became pretty clear that all of those considerations were well above my pay grade and I was just going to go do this. Okay fine. Then I also got informed—and I think I got this word at Headquarters—that I was going to a White House event, and it was the same reaction. “Uh-oh. This is probably some black-tie thing. How do I get out of this?”

But that didn't work either; I was stuck. Sure enough, I get the invite and it's a big deal black-tie White House dinner. Oh my. So back I go to Washington on the appropriate day. We always stayed at this fabulously elegant Holiday Inn right across from NASA Headquarters, which I suspect is not where too many state dinner guests stay.

I can do black-tie, of course, but on a rather meager budget compared to the kind of folks I imagine are also going to be at this dinner. I have a typical command performance perfunctory black-tie dinner in mind, like a conference banquet. I soon discover that you don't need to worry about any logistics for this event. A White House car will come get you. Gee, that's certainly different. Indeed, the White House car arrives, and in it is this absolutely delightful, tremendously handsome, well-kitted-out Army major in his mess dress uniform, on his very best behavior—being very formal and following proper protocol.

He meets me in the lobby, we get in the car, and he's starting courtesies and so forth, I just remember realizing, "Oh this poor guy! This guy thinks he got one of the really froufrou guests here." So I start right away to tone things down, saying, "I don't know who else is at this dinner, but you got the GS [General Schedule]-14. Sorry about that." We just start teasing along as we drive on over. This is when I see the whole guest list for the first time and am floored. It's a pretty impressive guest list.

He said, "Is there anyone on there you'd like to meet? Let me know." It's cabinet officers and all these different people. There are a number of people in here I'd love to meet, if you really could sit down and talk and ask them what's it like doing the job. But go up and be able to say, "Hello, Mr. Secretary, good to meet you," and have a snippet of a conversation—I'm happy to greet anyone there, but I'm not the kind of person that would do that and then go home and say, "Well, I met George [P.] Shultz [then secretary of state]." I don't know George Shultz

any more than you know him from reading him from the paper, other than I got to shake his hand. I'm looking at this amazing list, and I'm thinking what kind of opportunity would there ever be at an event like this to actually get to chat with one of these people. It's a formal event, so why would anyone in a public role be really open with someone they've only just met? All those things are swirling through my head, thinking this is going to be very strange.

We get over to the White House, and the flow of these events is just so superbly orchestrated. You just can't imagine. It turns out as a guest you need not know anything, understand anything, or do anything. Your entire evening from a flow and logistics point of view will go swimmingly. It's like the ultimate swan effect. You are going to glide elegantly across the water. All sorts of people's feet are going to be paddling like mad to make the logistics happen smoothly, and you're just going to glide across the water, not breaking a sweat or needing to really focus on anything. Your protocol officer makes everything happen for you. He was just a delightful guy.

We get over to the White House. He escorts me in. People come moving from left and right as you walk down this corridor. Your coat is taken from you; you never even break stride. If you'd like them to keep your purse, that's taken. You probably could quite safely give them your purse, it wouldn't matter. Then you're in the receiving line. I'm the ops geek, so I'm not staring around the room to see who are all the famous people I can spot, I'm actually intrigued watching how they are orchestrating the line and making it work for the president and first lady.

You meet the president first and then the first lady. He instantly knows your name. He's greeting you by name, and he's shaking your hand. He's saying something to each person that's particular about them. And you just think, "OK, so how is it that...?" And you spot these guys with the cards. The protocol officer gives the card to this guy who checks a list, and you can just

see the system that's been set up to be sure everyone is greeted elegantly and treated personally. This is not meant to feel like a cast of thousands fundraising dinner. This is meant to feel like a personal dinner with the president and the first lady and the guest of honor. And they're orchestrating the fine details to make it be that kind of experience just masterfully. Get up to the president and shake his hand. Although we had had a courtesy call in the Oval Office, it is different. It felt quite different, to be actually shaking his hand as a personal guest in a comparatively small gathering for a president and the first lady to be involved in. Then on into cocktail hour, a bit of milling about while they complete the reception line.

Somewhere in all of that, my escort comes up to me and says something asks if I know who I'm seated with. I said, "Not a clue." He goes off to find out, because one of their key points of elegance is to guide you into the room and directly to your seat. None of this hunting around for table numbers or having to read the card and bumping into people. He will know exactly where you're sitting, will take you efficiently there, seat you, and disappear. He comes back from that tour and his eyes are just a bit wide. He says, "Would you like to guess where you're seated?"

I start joking again, I said, "Oh I don't know the room, but lower left-hand corner."

He says, "Try again."

Said, "Whatever the equivalent is of below the salt."

He says, "Try again."

Said, "Okay, where?"

Said, "At the president's left hand." Then it starts to dawn on me just how special this night is going to be, because of course the seating is all driven by rank. The highest ranking table in the room is the president's table, and the next one is the first lady's. The ranking guest, if

it's a man—as it was in this case, the leader of Luxembourg—that guest will sit at the first lady's right hand, and his spouse will sit at the president's right hand. The next ranking spot is the president's left hand, and then the first lady's and then those tables, and on and on and on it goes.

So this young Major, who's actually seemed to loosen up a little bit, comes back and finds this GS-14 is sitting at the president's left hand. I bet he thought, “I'm probably dead. What did I say to her? Have I been too informal?” So that was quite a giggle. My table included the wife of the head of state, an American ambassador's wife, golfer Patty Sheehan, boxer Joe Frazier, and so that's one, two, three, four, five, so I'm forgetting several others.

It's an elegant room, fabulous table service, all of the protocol, pomp, and circumstance. The uniformed Army band is playing everywhere. It really was pretty dazzling just as a production and everything else. We sat down at dinner. Now, President Reagan also was Governor Reagan when I was in college. I went to one of the University of California campuses that was at the time notoriously liberal and had the distinction of having pelted him with eggs when he visited campus one time. That was before my time, so I was in no way party to the egg-throwing. It was a little bit of a famous, and at the time prideful, incident on our campus, and I'm now sitting next to this guy. I didn't by any means agree with all of his policies as governor—I was sixteen, seventeen, eighteen, so that was my opinion at the time—and certainly wasn't agreeing with all the things his administration was doing as president. So there is a politician sitting next to you, but there is also this human being sitting next to you. In a scale of an hour or whatever the meal service takes, at a table with just nine other people, that is a very human-scale interaction. The presence of the office is still there and the protocol and some of the courtesies and formality are still there, but it's ten people around a small table also.

I must say he was absolutely impressive on every single human level. The Army's strolling strings musical group came walking through at one point. I forget now what the military policy issue was at the time, but the president puts his arm on the back of my chair, leans over as they go by, and makes some remark about, "Isn't that beautiful? Can anybody really think that I willfully send such fine people into harm's way?" Which struck me as an amazing remark. Through the course of this evening and the different courses, he just orchestrated that table so deftly. I realized it was like watching a fugue. It really reminded me of a musical fugue.

There'd be just a little banter around the table for a while, with everybody chatting with their table companion to the left or right of them. At just a bit of a lull the president would look at one person at the table and say something to them by name, with a commentary that indicated he had at least a thumbnail of something of their background or something of interest. He had a personal, specific topic or question for each person at that table. He would offer it up, toss the ball across to that person, and they would reply, and they would have a couple of sentence conversation back and forth around that topic. Then in the most natural and gracious manner possible the president would put that topic to the whole table, and the whole table would spin again. So it was like all the instruments for a while. It was just like watching a conductor with a fugue. All the instruments for a while, and then he would highlight the flutist and have a few bars of the flute, and then bring the whole orchestra back in, and then tee up the violin, without the least bit of anything stilted to it.

I was thinking back to my earlier thoughts in the car with the young major about why would I just want to go up and shake a hand of a cabinet officer, if just that. It would be very interesting, but just being able to say I shook a hand, really what's that meaningful of that? Here

was the president of the United States orchestrating things at this dinner table so that everybody at this table in a genuine way could leave saying they had had a personal one-to-one conversation with the president of the United States. Something that was valid, it was true, and a remarkable thing to get to say. He was doing it so graciously. So that was just masterfully done.

Then you realize you're coming to the moment where there are going to be toasts. I'm wondering how are they going to do this? It's a big room. It's got however many tables in it. There aren't camera cables snaking all over the floor. There are no lighting stanchions set up. You realize you've seen these moments in the TV news, where the president stands up and is making a toast. It looks like a properly produced, well-lit TV production. What are they going to do? Stop this for twenty minutes and haul in cables and stuff? Then the faces of the two vertical columns on the opposite side of the room swing back, and I see all of the technical lighting is preinstalled and preaimed for the moment.

Again, it was all so smooth and efficient. The columns open up. The doors open and X number of press people come just a few steps into the room. The president stands up, does his toast, click click click click snap snap snap snap, and—poof!—the press guys are gone, the columns close and we're all done.

We adjourned from there, for coffee and dessert was going to be in the China Room. I'm thinking, "Gifts from heads of state of China. Why else is it going to be called the China Room?" We get there, and it is a room with recessed lit cabinets around both sides of it, displaying the table services of previous presidents. It was there that it really began to sink into me more deeply just how amazing it was to be a part of this event and to be at the White House. I have my cup of coffee, and I'm looking around the room. I'm standing in front of one of the

cabinets and looking in at the china service on which President [Ulysses S.] Grant hosted people at the White House.

My brain did one of those collapsing of history things of realizing that someone in the height of the Civil War, someone just like me, sat in that same room and had a dinner and maybe the same kind of conversation, while all sorts of issues and wars swirled around in the world outside. Someone just like me had their meat, their dessert, and their coffee on that plate in that room at the middle of the Civil War. That unity of so many threads of history was really pretty impressive.

Then we went down to the East Room, I think it is, for the evening's entertainment, which was the Alvin Ailey American Dance Troupe, which is a pretty avant-garde troupe. I remember hearing quite a bit of buzz I think among people who probably followed the personalities of the president and the first lady more than I tended to. There seemed to be quite a bit of a buzz of, "Isn't this a bit risqué? What's Nancy going to say about this?" There even seemed to be some people every now and then leaning out to look down the row and see if she was smiling, grimacing, applauding or looking like she was about to leap from her seat and stop the whole thing. Then there's a little bit of music and dancing, and I guess that was when dessert was.

Then at something around ten-ish, whatever their schedule calls for, there's a moment of not particularly much fanfare where the president and first lady just go upstairs. That clearly starts a timer with the protocol staff. They won't be unseemly and shoo anybody out too rapidly, but they're also not going to let people just linger forever. Things wind on down from there, and so that was the evening. I'm quite terrible about thinking to bring home the menus and invitations from events. I don't tend to grab those things as souvenirs, but I'm happy that I had

the presence of mind to grab these. So I do have very a nice piece framed on my wall at home that has the place card, the menu, and the program of events for the evening. It was a pretty special memory. Once it was all done, I was actually glad that I didn't manage to talk my way out of it. Even my dress worked okay.

ROSS-NAZZAL: Did you talk with the president that night about the National Commission on Space?

SULLIVAN: I don't recall talking to him about that. He asked me about the spaceflight, and I talked a little bit about that. If I recall correctly, I think he mentioned by way of lacing the table conversation together. I think he mentioned to the rest of the crowd that "Dr. Sullivan is serving on the National Commission on Space that we've just formed," but that was as an aside. We talked about the spaceflight.

ROSS-NAZZAL: Who else was on that National Commission on Space?

SULLIVAN: It was led by Tom [Thomas O.] Paine, who had been the NASA administrator for a period of sixteen to eighteen months. Tom was the guy in the NASA administrator's seat when Neil [A. Armstrong] and Buzz [Aldrin] landed on the Moon. Tom chaired it. Neil was on it. Ambassador Jeane [J.] Kirkpatrick was on it, plus Laurel [L.] Wilkening, Luis Alvarez, Chuck Yeager, George Field and a number of others. I usually have copies of it, but I would have to go look up the rest of the roster. It was a very interesting group of people. I guess I don't have my copy here.

ROSS-NAZZAL: How did the group function? You've listed some NASA people, then you've listed some people involved in politics.

SULLIVAN: Ambassador Kirkpatrick was on it because international dimensions have been a part of space policy and space program planning since the very dawn of the space age. Competitive dynamics at some points and some cooperative dynamics at others, also the leverage of “there are only two spacefaring countries so you want to cooperate with me” to draw and keep allies. There's been a strong international policy component to US space decisions, military and civil, all the way along. So it's '84, and there's everything from talk of going back to the Moon to talk of going to Mars. It's still a time of tension between the United States and the Soviet Union.

There were people like Carl [E.] Sagan advocating a joint US-Soviet manned mission to Mars, specifically to create a mutual obligation for the safety of a combined crew that he imagined would prevent greater hostilities from breaking out on Earth. There were viewpoints like that abroad in the space community when we were impaneled. I suspect Ambassador Kirkpatrick was put aboard to bring a grownup voice of realpolitik wisdom to any such deliberations, and some more sober, wise experience from her point of view than some of the optimists or the space aficionados might otherwise have. Who else was on it? I want to say Gerry [K.] O'Neill was on it, but I'm not positive. We should Google it right now and find out who I've left out.

We met as a group to try to arrive at some conceptual framework for what are we going to do. It's an immense topic with a tremendous number of threads running through it. What are we going to try to do here, and how are we going to get our arms around a set of processes that

gives us a reasonable way of adding some value and saying something meaningful to the president? Like I think every group of that sort does, you work hard to pick topics and develop incisive insights in the hopes that some of the things you say may actually end up being acted upon. You don't put that much time and effort into something and feel content if it just ends up as a doorstop somewhere. You hope something actually triggers action and makes a difference. There were lots of meetings of the whole working on that.

We went through a phase where things were more splintered. There was one guy who was a really keen and passionate advocate for much more international cooperation. Use it actively as a tool, be more expansive, it should be an explicit part of our foreign policy. There were other folks more just attuned to particular technologies. There were folks who were strong advocates of particular destinations, from a Station as a permanent habitat to back to the Moon or on to Mars.

All of that swirled around both within the group that had been impaneled and among many, many other people who had not gotten on the panel but wanted to be sure their viewpoints were well heard. We had white papers coming at us. We had solicited and unsolicited communiqués of various sorts. We set up quite an extensive array of public hearings from Ames, Iowa, to major cities. So trying to cover all of that. Over time, we arrived at a construct that we thought got at the core purposes a civil space program should pursue, which was one of the elements in our charge. The other major one was to say what goals or objectives or accomplishments might be the targets for a twenty-some-year horizon.

Tom's own experience shaped a fair amount of this, of course, as you would expect. When he got on the airplane to fly to the Cape [Canaveral, Florida] to see off Mike [Michael Collins] and Neil and Buzz, he had on his desk a stack of view foils at the time. Today we'd call

them Powerpoints. They laid out the game plan for how to put people on Mars with Apollo technology by 1985. Now here we were in 1985, and he's chairing this commission. We don't have a Saturn V anymore, and we can't even get to the Moon. All the wizards appearing before us are saying that the prospect of putting people on Mars is twenty to thirty years away at best. He would just bemoan the fact that in the almost twenty years that had elapsed, the target had moved more years out in front of us, not gotten closer at hand, because he was a real passionate advocate of the visionary power and the technologically transformative power of a big bold goal like Mars.

This was the first big such evolution that I had been in, and I was by leaps and bounds, chronologically and otherwise, the most junior person in the room. I learned tons about leading this kind of process itself, and the ins and outs and challenges of shepherding such a group. That there's a deft combination of loose but tight control that you need to be almost continually adjusting. Tom was pretty masterful at that. It was fun watching him. He became a delightful mentor during this time. We had lots of good long conversations about all sorts of different topics. Eventually we arrived at a construct that I was happy to be able to contribute a bit to.

It's a role I often play in groups—the listen and play back and able to synthesize—whether it's my own senior staff or larger groups. It's often helpful to have someone who can find a way to step in and say, “Okay, so let me try to replay back what I think we've just been through in the last hour here, and see if it captures it right.” Actually synthesize, not just laundry list, and see if by doing that synthesis you can help the group move further and deeper into their thinking process. I got to practice goodly bits of that with this group, and sometimes to good effect.

We came up with a simple construct that was why should we have a civilian space program, and one I think was something like—I won't remember quite the phrasing of it now. One was knowledge, one was exploration—with the actual discovery and mapping and finding new worlds. One was enterprise. That was the somewhat novel note to sound at that time, but it was trying to sound a note towards consciously accelerating and strengthening the efforts to tee up and enable a richer, broader array of private sector enterprise, not just new mixtures of government programs. Tom also decided that we should go ahead and publish it with a trade publisher. He lined up Bantam Books. This was in the hopes to try to avoid sixty pounds of paper from the Government Printing Office that just sat on shelves. We would write it in real human being English, like a book you might actually want to pick up and read.

Also, he knew Bob [Robert T.] McCall. He persuaded Bob McCall to create the cover art for us. Bob created just a fabulous piece. It shows a Martian landscape with a very active, inhabited operations base. In the middle of the front cover, there's a little guy in a jet pack standing on a small knoll. If you peer carefully at the bottom of the backpack you'll see TP on it, so he actually put Tom on Mars. Tom also had the thought of taking that classic Chesley Bonestell 1951 painting that represented [Wernher] von Braun's visions of a Station on orbit, a craft that shuttles back and forth (the Orbiter), and a telescope above the Earth, and asking Bob to update it. So the frontispiece is the Bonestell painting on the top about five by seven, and Bob McCall's update on the bottom. I have used that pair of pictures for presentations. It took me years to finally find a slide set that had the Chesley Bonestell painting and permissions given and so forth.

It is a fabulous pair of images for me in terms of my own story, and I hope I use it to good effect when I subject people to hearing the story, because the first painting was done the

year that I was born. One of the magical things about it is nobody has ever done any of the things pictured. It's 1951. It's six years after the close of World War II. It's six years before Sputnik. The only known things that even hint at what's in the painting that anybody on the planet knows are the ballistic rockets that the Nazis used to attack Britain. That's pretty well the extent of human experience in space at the time. That's what space has been. We're only six years away from that.

If you think back to those times and recall the Marshall Plan, Britain is still on its knees, and so is much of Europe economically. Von Braun's got these visions and so did Willy Ley and others. Bonestell makes this painting and represents an experience no one's ever had. There's this fabulous arc of the Earth in the background with Central America. It's all very recognizable. It just reminds you how fabulous and powerful the imagination of an artist can be.

Then I go to the McCall picture, which was painted when I was 35. The little public school girl from southern California who grows up loving languages and flying Cessnas, by the time she's thirty-five has lived this picture. Now you see the real Shuttle, not Bonestell's odd black craft. She has been a little bit a part of the launching international discussions of the Space Station, which now looks like the truss and girder thing, not like the 2001 smooth wheel. She is actually already assigned to fly the Hubble Space Telescope deployment mission. The telescope in the Bonestell picture looks like a Tylenol capsule somebody pulled apart.

These are fabulous bookends to my own story. Thirty-five years is on one level a long time and a slow rate of change, but these are pretty momentous capabilities to have emerged over thirty-five years. In the historical scale, thirty-five years is the twinkling of an eye. In fact, much of this stuff didn't exist when I was in high school. It's incredibly fast, and it is a huge commentary on this moment in the arc of history that we've been able to live, this first moment

where human beings mastered the directed control of energy enough to be able to do this, and it's just first baby steps, but it's still pretty remarkable.

We have all lived in that timeframe, as citizens of one of the nations that played a really pivotal role in driving it forward, and by and large doing our very best to be sure that it was used for constructive purposes. That's a pretty neat story to have been a part of. Then in my public speaking, nowadays of course I quickly slant it towards a picture of a little kid over in the science museum that I run. What are we going to tell this kid? Are we going to tell him, "Gosh, it's too bad you didn't have the good luck to come along when Kathy did? It's all harder and worse and bad and awful now, and I guess you just don't get such a good shake." Are we going to tell him that? What are we going to tell him, then? "Sorry the school system's not as good now as when she came along. Too bad. Guess you'll just have to settle for less." That's fun to use that bit of a bookend. That was an interesting process.

We were on solid track to publish our report in early February 1986. Of course, were eclipsed completely by the *Challenger* accident. Probably in the end, I'm sure we didn't have anything like the effect we had hoped to have. There's a lot of commonality, number of points of commonality, between the Paine Report and the about a year and a half later Ride Report. Sally chaired that effort for the agency. It had the virtue of being internal. Agencies always prefer internal reports to external reports. Sally sounded a much stronger note than we did on the Mission to Planet Earth, the Earth perspective that space offers, putting a focal point on that, which paid some real dividends and did a good thing. I think my best hope for all of the work we put into the Paine commission would be that I think we latched onto some sound and right things and gave them some fresh perspective. A goodly number of them were picked up,

reflected, and amplified in some cases in the Ride Report, which did seem to get some traction in NASA. It was still a great experience.

ROSS-NAZZAL: It sounds like a great experience, just getting to work with all those people and picking up all those fantastic skills.

SULLIVAN: Oh yes, Laurel Wilkening and I have stayed in contact, still are in contact now. Not too many of the other folks on that group. We all did scatter. Ambassador Kirkpatrick played her role brilliantly. The guy who was our international advocate said, "I'll write up the cooperation part of the report," and wrote largely his vision of what he wished would be there, which I could tell most of the rest of the commissioners really had issues with. But you're trying to keep things constructive and civil and work the issues, not smack people down. The ambassador had not attended most of our sessions. Her schedule made that impossible. She had told everybody that she was not going to be able to be a routine sitting member of the panel, which was fine. But Tom sent her the manuscript at this juncture and said, "We do want you to have a look at where the draft is heading and hope in particular you'll give us your advice on the international sections." Of course she went through that and put it much closer to places where the rest of the group felt was appropriate. It was a masterful finesse. Really, what's the other gentleman going to say? "I beg to differ with the ambassador. I think we should stick with my draft." It was gracious, well-done, and accomplished all of the right things and left him plenty of face saving as well, but got things back to a more sensible point.

ROSS-NAZZAL: Was there a chapter that you authored in that manuscript?

SULLIVAN: If you want it to read like one book, at some point it has to be written by one group or one hand. You've got to decide what voice, and you've got to just pick someone who you have confidence can put it in a unifying voice without sanding away all of everybody else's viewpoints. You just have to let that happen. I did a lot of writing and worked a lot with Tom. I had been seconded over to this thing full-time and had another flight assignment coming, but it was down the road a goodly way. I was able to put a fair bit of time in it, especially in 1985, and did a lot of writing of drafts. As I mentioned, I played that helpful playback mode. I was pleased with the taxonomy we ended up with.

It came out of a really intriguing, fun discussion. I enjoyed getting to play that role of helping jell the phrasing and the conceptual framework, and then we went about filling that out. It was in the end, I think, really Tom and one other contractor who sat down and just combed it through, and a final editor put it into a voice. All of us, everybody on the panel, quite legitimately has intellectual content in it. There are fairly big blocks of text in different places that are close bits of chunks that I helped Tom write, because I was able and willing to be one of the writers, but all of that got massaged back into a unitary whole.

ROSS-NAZZAL: Let's talk about the next flight, STS 61-J, that you were assigned but didn't end up flying. When you were selected for that flight?

SULLIVAN: The Hubble Space Telescope (HST) was meant to fly in either very late 1985 or early '86. It was originally just me and Bruce McCandless [II] assigned to dig in on the EVA and the servicing aspects. He'd been the office representative and adviser to Hubble on the

whole philosophy and design of the EVA servicing for quite some time. So I joined up with him, and we started working on getting ready to put the Hubble in orbit.

Hubble was supposed to be serviceable on orbit for fifteen years. We were assigned ahead of the full crew so that we could spend extra time being sure that all the EVA tools and procedures were in place to accomplish those servicing aims. Makes good sense. Bruce, I, and all of us in the office at that era, had just lived through Solar Max and the PALAPA/WESTAR retrieval missions, both as observers and technical advisers. Bruce was on the STS-41B MMU flight where they deployed those satellites and played a role in setting up the repair and retrieval that Dale [A.] Gardner and Joe [Joseph P.] Allen later did.

So we've lived these events, and certainly one of the big takeaway messages of those flights was what happens when you've got something in orbit that you need to go service, but you didn't really think about it in advance. When you realize you have to go do it, you take out the engineering drawings, which are supposed to give you the as-built/as-flown configuration. You design a tool based on that that will go grab, clamp on, whatever it needs to do, and let you capture this thing and service it. In the Solar Max case the TPAD (the Trunnion Pin Attachment Device) mechanism functioned fine, but the spacecraft side had a tiny little obstruction that was not reflected in the drawings, and that prevented the TPAD grabbing on the way it was intended.

There was a broadly similar circumstance in trying to retrieve the PALAPA and WESTAR. You figure out a clever way to go grab this thing, and you get up there and just tiny little things that didn't appear in the drawings, that didn't get accounted for in your plan, force you into a plan B. Now we're a very clever bunch of people, and we come up with plan Bs, and manage to do both of those servicing missions, but this is different. It's a major national scientific investment, and we know we're committed to servicing this one. We can't consider it

acceptable, when we know in advance that we're committing the agency to fifteen years of servicing this thing, to have little stuff that bites you again. You just can't get up there and discover, "Oops, sorry, wrong wrench, can't do this." That's just not acceptable.

We have about a year to dig in and do everything we can to make sure the little gotchas that almost got us on Solar Max and PALAPA/WESTAR do not ever happen on Hubble. At a minimum, let's think about those deploy mission mechanical events that have to happen, in order to deploy it, and be dead flat sure we've got tools to backup those functions. We have to know that the tools work, and that we've got really excellent detailed procedures: it's on the arm; you position it, where? Where are the EVA crew members, how do they get there, where does the foot restraint go? Which length of an extension on the socket wrench do you need? All of the typical level of great detail that you would plan for an EVA needs to be done. We need the items that are potential deployment mission failure modes; we need those very exactly accounted for.

The next thing to think about would be the most likely or worst case juvenile mortality failures. What might spark a very quick servicing mission? Something fails in the first 30, 60, 90, 120 days, you'd accelerate a servicing mission to go fix that. What are those most likely failure modes? Tools and procedures should be ready for those when you launch the deployment mission. Then the deeper slice of things is the whole list of orbital replacement units. The design has been set. The agency has committed to a list of things that are considered replaceable on orbit, and we need to have the toolkit and the procedures to do those. That's what Bruce and I set off to do—work through all of that.

Fast-forwarding a bit, when the *Challenger* accident happened, two things became clear before long after that. The first was that, though it's totally unclear when the Shuttle will fly

again, you know it's a long way off. Also, when we do next fly, the priority sequence of cargoes that need to get up is going to be different than it was. You're not just going to pick up a calendar from 1986 and start flying that out again. You're going to rethink the sequence of payloads and adjust. You just lost a Tracking and Data Relay Satellite, for example. The TDRS satellite that was meant to be the third one is going to jump up to the front of the line and become the number two that was lost in *Challenger*. Those are two things you can be pretty sure of.

It's going to be a long time, and a payload like Hubble, not infrastructure-critical to manned spaceflight and not a paying customer, is probably going to take third place behind the orbital infrastructure and paying customers. So we're probably in for a good long wait. I really credit Bruce for this recognition and leading the charge on what this could mean for Hubble servicing. We'd both love to fly sooner rather than later, but we already know the telescope well enough, so we're probably sticking to the telescope. We're sliding downstream in the flight manifest with the telescope. The best thing we can do, then, is use however much time this turns out to be to continue to dig further, deeper, and make all of the servicing preparations even more robust. That's what we did.

We had worked under pretty good time pressure in 1985, but by February of '86, we realized we have a lot more time now. Let's phase out what we need to do over a longer period of time, and let's think about the other dimensions we ought to add in. Ron [Ronald L.] Sheffield at Lockheed Martin, who was the anchor player on the Lockheed side of all the servicing mission preparations, he had exactly the same idea and mindset. Pretty quickly his little group, Bruce, and I sat down and said, "What are all the other things we *ought* to be preparing for? Never mind what's on the approved and confirmed list of orbital replacement units, what's the next list of things that could fail over the telescope's lifetime, and what are the barriers to making them

replaceable on orbit?" In some cases it was, "Well, they're planned to be installed with some other kind of fastener." "Okay, so how big a deal would it be to change all those fasteners and use the same replacement fasteners that we use on all the other ORUs [Orbital Replacement Units]?" Then, we could have even more opportunity to extend the life of the telescope, because we could replace those as well. We added some other tools, just kept expanding and detailing more devices and the matrix of tasks and tools that we knew we had to work.

We knew that some fellow astros are going to get an assignment someday to go fly up and rendezvous with this telescope and fix it. As deploy crew, we had the benefit of still having the telescope on the ground. So we could take the tools and the checklists we've written and prove they worked on the real vehicle. How do you replace a DF-224 computer? I'm going to take the tools, the checklist, and two spacesuit gloves. We're going to go to California, and with the cognizant engineers and the safety guys right there watching us, we're going to replace the DF-224 with EVA checklist, not the ground servicing procedure. We're going to verify the flight checklist for how you take out a DF-224 computer.

This made them crazy, of course. Our position was that somebody was going to do this job in orbit someday, with none of the ground experts at their side. What better way to get ready for that than for me to do the exact same procedure on the ground, where an expert could put his chin right on my shoulder and coach me if I'm about to screw something up? He can give me cues and guidance. He can watch for himself how all this works. And he can train the next guy who's going to be his replacement when the spacewalk task finally comes, and we can all go to bed knowing we actually know these tools work to do this job. I know how to pass the knowledge on to the spacewalkers, and you know how to pass the knowledge on to your guy, so let's do this.

We fought through lots of those battles and took basically every single Hubble tool out to the flight vehicle. Confirmed just about every single fastener and every single fitting does fit the designated tool. Verified that you can reach it. Recorded the exact level of torque and number of turns on every fastener. We wanted to comb out all of that level of detail so the folks who ended up doing the servicing missions had that level of confidence. How I looked at it was—I'd love to go do the servicing mission, and maybe I will get that opportunity, but I should operate knowing I could get hit on the freeway tomorrow, and I want whoever ends up doing the servicing mission to have the highest confidence possible there is not a little gotcha up there. This tool and this procedure, they will work. They have worked on the flight vehicle.

It is no small deal to get yourself trained well enough to do the repair job itself well. I wanted the servicing crew to be able to totally put aside worries like, “I wonder if it's actually reachable?” Put that aside and focus on the other complexities of doing a Hubble servicing mission. That's what we aimed to do.

One of the cool paybacks that I enjoyed from all of that was watching the servicing flight [STS-109, March 2002], when they swapped out the Power Control Unit [PCU]. This is an immense heavy box that just has this dense forest of big two-inch, inch-and-a-half-round thirty-some-pin connectors down one side and a very tight crowded set of fasteners all around it. The equipment bay it sits in leaves you not much room on either side of it, and it is essentially the nexus of the central nervous system of the Hubble telescope. All of the power switching goes through there. We started working on the question of how you could replace the Power Control Unit. All we ever heard was, “You can't. It can't ever be turned off.”

“Yes, yes, okay, but suppose we ever needed or wanted to?”

“Well, you can't. It can't ever be.”

“Yes, I know, but suppose the day came.”

“Well no, you can't. It can never be turned off.”

“Guys, if the PCU has died or is one failure away from dying, do you really think you're not going to try to replace it?”

“Well, no, maybe then I would try to replace it.”

“Okay, so how would we do that?”

“Well, you can't turn it off.” We were just trapped in the dead-end logic boxes of some of these folks.

“You can't do that because we've said we never will.”

“Okay, but I'm interested in the day that we discover we're just going to have to do it anyway. How would we do it?” We finally moved most of them along.

We obviously couldn't rebuild the telescope at that point, but we had a bunch of clever engineers, especially Ron and Bruce, plus a lot of savvy ops folks, and together we came up with a set of relatively minor mods [modifications] that could be done so that when a spacewalk crew ever needs to get in there, you've made it easier to get a tool onto the fastener. You've given them a little more room. Another tack we took was to say, “If they can just get the old one out, what you want to do is design an adapter that lets you install a new one in a slightly different way, because getting your hands into these places to attach new connectors was going to be a real bear.” So we had the opportunity to think ahead about some of those complex jobs.

Low gain antennas were never meant to be repaired and replaced. With little more than a fastener change, they could go on the list of things that you could change out. Not all of those things that we added to the list have needed to be used, but some of them have. Some of them, like the PCU change out, that's a major save that goes back to this whole little squad of people

that teamed around, always third shift, always when all the other stuff wasn't being done. That goes back to that little squad of people, Ron Sheffield and his guys, Bruce, and me, just hammering away.

We'd bring the toolsets back and do engineering validation runs and procedure validation runs underwater at the Weightless Environment Training Facility. Bruce and I could have done all those tank runs ourselves. It's great fun. I love to get in the tank. I'll take all the tank runs I can get, but we also very consciously reached out and tapped a subsampling of a couple classes junior to both of us, to be sure that—again if either of us get hit by a truck—there's two or three folks that have been in the water. They've been to California and seen the flight vehicle. They came out on one of the tool fit checks and/or they've gotten in the water with one of us and done a run. So we're transferring that knowledge. A number of those folks ended up on Hubble servicing missions.

My name is not on any of the servicing patches, but I have to tell you with what Hubble has done and the role that I got to play in Hubble—if you strip away lots and lots of cool things from all of my fifteen years at NASA—that's probably the deepest abiding pride. In a very, very real way I got my fingerprints on every Hubble accomplishment. One mission patch and all the accomplishments. That's pretty fun.

ROSS-NAZZAL: When NASA Administrator Sean O'Keefe decided that we weren't going to fly to Hubble anymore, were you part of that group of scientists who tried to convince him otherwise?

SULLIVAN: No, I really wasn't. I was in Columbus at the time, running a business here, and busy with plenty of other things. It's easy to understand. It's an incredible spacecraft, and it's done incredible things. On the other hand, I could also see a rationale for the decision. Hubble was conceived of and programmatically was part of an integrated plan called the Great Observatories. There was an optical one, called Hubble, and a gamma ray one, and an infrared one, and there was meant to be an ongoing sequence. Hubble was intended for a fifteen-year life. It had had its fifteen-year life. Sean wasn't proposing to shut the switch off prematurely. It was at the fifteen-year life point.

There are two other telescopes moving along program milestone tracks towards needing budget authority to start to build them up. It's not that there's anything wrong or bad or unfruitful about Hubble, but you've also got plans and commitments to other communities of astronomers for different designs with different technical capabilities and different instrument suites. If the Congress is not going to appropriate extra money to do both simultaneously, what decision do you make? You delay the guys that were told they are in line for right now, and you tell them, "Well, it's not right now, it's somewhere later?" Or you tell the guys that are active now, "You guys have had a fabulous fifteen-year run, and that's the run that we committed to you." So it's not, "turn the switch off because, sadly, the vehicle died," it's "turn the switch off because your turn is over." It's a tough call.

It's a really tough call. It's a right and good thing to have advocates of both sides speaking as compellingly as they can to the pros and cons of different courses of action. At the end of the day, the person sitting in the seat of NASA administrator is expected to make tough calls like that, and the pros and cons of which community wants what telescope is only one of the inputs.

ROSS-NAZZAL: Where were you when *Challenger* happened?

SULLIVAN: I had been in California. The short version is we were out on the West Coast at Sunnyvale [California] with a bunch of the Hubble tools, doing another one of these couple of day third shift in the VATA, the big Vehicle Assembly and Test Area, a gigantic clean room where Hubble was. Working through some more of this tool verification matrix and documentation. Don't ask me which one of the suites of things we were doing that night. It was two or three third shifts in a row. A long sequence of days. Was pretty exhausted, and I hopped on the airplane, early morning California time on the 28th, to fly back. I flew either San Jose [California] or San Francisco [California] to Dallas [Texas]. Landed at Dallas, had a connection hopping into Houston, and I got off the plane in Dallas.

It was still a reasonable time of the day, maybe early afternoon. I had been thinking about going on in to the office, and I think I told my secretary that I'd be in once I got back to Houston. When I hit the ground at Dallas, I realized I was just so exhausted I was going to call in, let her know where I was and tell her I was going home. I'm wiped. Jessie [Gilmore] was my secretary at the time. I just started in with something like, "Hi, I'm checking in. Just exhausted, I don't think I'll come in."

There's this odd pause, even as it was happening. Something seemed odd about the pause in her reply. Then she said, "Didn't you hear what happened?" I realized, "Oh, I'm not going to like the rest of this." I'm thinking, "This can be anything from a major vehicle anomaly that could jeopardize just the manifest because it's going to need troubleshooting or repair." It

could be, I'm thinking, maybe worst case, the Shuttle went off the runway somewhere. I don't know what I'm thinking, but this is not going to be a conversation I like. I said, "No, what?"

She said, "The Shuttle exploded." Just three words. It was an incomprehensible sentence. It doesn't compute. Too short, too abrupt, makes no sense. Just couldn't register was my first reaction. Then it started sinking through, and I could hear the sobbing and the crying in her voice. I don't remember any of the rest of the conversation. It probably didn't last very much longer. Hung up. Made my way over to my gate. As I went through the concourse, people are clustered by televisions, and I became aware there's oddness in the air around me.

I get around the gate area, and the gate is abuzz with what's going on. I start to get the sense that lots of people on this flight but me are journalists who are now hurrying down to Houston to start covering this story. I start hearing snippets and bits of their commentary, most of which just struck me as ridiculous and disgusting. No one knows virtually anything yet, but they're starting to compose their storylines. I'm hearing them as very ill-informed gossipy storylines that are going to boil down to, "Oh, the poor teacher! What a tragedy! What a bunch of screwups the NASA guys are." None of which makes me very happy.

I lost four classmates and a dear friend from the next class, scarcely knew [S.] Christa [C. McAuliffe] and didn't know Greg [Gregory B. Jarvis] at all, and these yahoos think that a teacher dying is the great tragedy here. Excuse me, there were a few other people on that vehicle, some of whom had only sworn their life to service of their country. They didn't win the prize and get the ride. They actually were committed to this. That and a thousand other angry things of course are swirling through my head.

I found myself, unfortunately, in a six-seat-abreast airliner flying down there, and I was in a middle seat. All three guys in front of me seemed to be journalists. All three guys behind

me seemed to be journalists, and the guy on either side of me seems to be journalists. They've all got their little recorders, radios, or whatever they're listening to. They're all just trying to suck up the latest and gossiping amongst each other and bandying things back and forth. I'm just composed enough to realize, "If you say a single word that makes them realize you're an astronaut, you're dead. They'll be all over you. No good is going to come of this."

It's not even really registered in my head. I don't know. I haven't seen anything; I don't know anything. I know I really don't like the way they're talking about this. I'll probably jump down somebody's throat and that's not going to be helpful to anybody, so just sit still. The only mercy in all of this is that the flight was only about forty-five minutes. I think I only bit halfway through my tongue. Got out of there and just went straight over to Building 4. It was just one of those times that there is no place it is good to be, but the only place that you can stand to be is in a place full of people who have some sense of what this is about and who share in a way that you don't have to try to explain, because these are not explainable things. How do you give somebody enough context to understand what any great loss means to you? Painful losses are just too hard to talk through all the things that create the context and make it so painful, and it's part of what makes grieving such an important process, but a hard thing to share.

All of that is swirling everywhere, and there's already scads of flowers outside by the Space Center sign. The flags are already at half-staff. You're driving back to your home and your very familiar workplace, but you are also driving into a world you have never been in before. It was very strange and very painful, and I knew it was going to be very strange and painful and disorienting for probably an extended period of time. I just went back to Building 4 and stayed.

ROSS-NAZZAL: Was there any discussion about what crews would be doing at that point, or what astronauts should be doing?

SULLIVAN: Oh no, not that same day. The world had just stopped. The world had just stopped. It was like software halt—frozen. It was just wondering, just dim, just grabbing each other, patting each other, needing to look at someone else who you didn't have to say anything to. Your eyes could just say, “What could this have been, and how did this happen? What could it have been, how did it happen, how did they die, what does it mean, where do we go from here?” All those questions are up in the air simultaneously. You know intellectually that some insight about each of those will emerge over time. But at the moment, there's no insight around. And you're not on the flight team. If you're on the flight control team in mission control or the launch control team in Florida, you're a little more caught up still in the process of data capture or writing things down. You actually witnessed something, so you still can't make any sense of it, but you've got some mechanical sorts of things to do to try to capture the moment. The data that will let folks over time make some sense, deconstruct, and figure out, “What do we need to understand of what happened here.”

I wasn't that. I was asleep on an airliner when the vehicle blew up. I was off the planet in this nice little hermetically sealed tube when the vehicle blew up. The world was normal when I got on the airplane, and the world was totally different when I got off the airplane.

I just knew it was going to be a long, long time before it made any sense. Big losses were not by any means new to me. I'd lost a best friend from grade school to leukemia our senior year of high school. I'd lost the one grandparent I knew in sixth grade. I'd already lost my mother seven years before this. So I was all too familiar with these moments where everything

just seems to have stopped. I remember talking to somebody, I think it was Kitty [A.] Havens actually, who was an EVA flight engineer at the time and just up around the third floor talking to everybody. Kitty and I just had one of those hollow-eyed conversations. It was just, “Kathy, I just don't know. What do we do from here?” Just drawing on my past, I didn't have a real meaningful answer to that.

The survival level answer that I knew from earlier times is when you don't know any of the pieces to any of the other answers, that you really deeply need to know, you get up each morning. You pick at least one foot up and move it the tiniest bit in front of the other foot. If that's all you can do all day, that's fine, but you at least do that. You just find ways to keep going. Don't go to halt. Don't stagnate. You just find something to keep a little something moving, a little bit of psychic motion to the system. As incredible as it is when you're right in the bottom of that pit and it's just silent and dead, life will pick up and go on. You will get back to somewhere that becomes normal again, and it will happen. You just can't tell when entirely, and you can't tell all the steps in between. If you just stall completely, that's when you can fall off the edge of the Earth and get even more lost. That was it. That was the only thing I knew. We'd get up each day, and we'd come in. We'd do what we could to put one foot a tiny bit in front of the other.

ROSS-NAZZAL: Did you do anything at all with the families of the crew members?

SULLIVAN: Yes, I was not one of the casualty assistance officers, because we were buried in the Hubble stuff, but I did my share of the rounds, the visits, and the courtesies to all the different families. In particular, the notable strand of things for me that started from that was Dick

[Francis R.] and June Scobee; I felt particularly close to them. In fact, two student interns that June knew from Texas A&M [University, College Station, Texas] had rented a spare room in my house and bunked with me for a number of terms. We'd had a fun good relationship and rapport for a number of years.

So I started spending, as the weeks went on, more time at June's house as the courtesy crowd sifted away. June was just starting to think about this idea of there needing to be a living memorial that was about something constructive and inspiring, like education. People are going to name buildings and streets and do inanimate things to commemorate the crew and that's all fine, but it was already becoming important to her that something alive come out of this that was more in keeping with the spark of inspiration, learning, and curiosity that the crew had come to appreciate together, centered around Christa.

I spent lots of evenings just letting her talk. It was all very vague and ill-formed at the time, just letting her talk about what she's imagining. Teasing her out, "Tell me more about that. Why is that important? What would you like it to be doing?" And then doing my playback thing. "You could do something like this. What if you did it like this? So suppose it was like that?" Lots and lots of evenings like that, which over some weeks culminated in her asking me to join the effort and take on the challenge of designing the Challenger Center Program. I ended up conceiving of the simulation base, the distributed set of learning centers, and multiple museums. All that came out of those weeks. We chose to center it on a simulated mission to Halley's Comet, since Halley's Comet was a cornerstone of the [STS]-51L flight. That whole saga started there, and what became for me ten years of involvement with the Challenger Center, heading up the education program design and development.

ROSS-NAZZAL: Other than working with the Hubble Space Telescope tools and possibilities for EVAs, were you working on anything else between the time that you flew STS-31 and *Challenger*?

SULLIVAN: Between *Challenger* and 31?

ROSS-NAZZAL: Anything notable?

SULLIVAN: I did not get caught up officially in any of the accident investigation and other roles. It's probably wise to deploy only the people you really need to do those kind of duties. There is also something else to be said, I think, for doing more than the office managed to do of providing ways for everyone to connect to the task of taking things forward. I quibbled with a couple of the leaders of our group about that now and then. I don't know whether it was tactics, pain control, or what it all was, but there was only a tiny nucleus of people from the office that were involved closely in the investigation. Sally on the Rogers Commission and a few other folks on certain tasks. Everyone else was told, "We'll let you know when we know."

I thought, "It's not even a smart way to use the time and energy and talents that people have here." There are some fairly simple things that one could do to let more folks within the office engage in some bit of the recovery and investigation. I want to help us go fly again just as much as the next guy. I went off and attached myself to, I think it was Mike [Michael J.] McCulley who was assigned to look into the documentation on prior reports of O-ring incidents and anomalies. I just went out and said, "There's got to be something that others of us can do to help move this all forward." I conspired with him and picked up a couple pieces of work there,

pulling some of the background data and doing some of the synthesis of how many events. Just feeding him, "Here's what the data from the other preflight reports seem to show." There wasn't a real distinct pattern, but there was a greater frequency than had been apparent. I was looking for things like that.

I got Mike to grab an airplane with me one day and fly down to the Cape, because I had reached a point that it was important to me to get to go see the debris in the debris hangar. I flew on *Challenger*. I had crawled all over the payload bay. Last time I saw it, I was kicking tires and walking away on the runway. I helped integrate a payload like that for STS-6. We flew down to the Cape, and he had the access stuff to get us into the debris hangar. We just walked through. I just somehow need to see what this stuff is. Had some sense that it would play a role in completing something for me a little bit. It did, in odd ways.

There was the same bizarre juxtaposition of things that you see after a terrible fire or big earthquake. I remember seeing the spreader bar, this huge I-beam structure that carried from the forward to the aft trunnion pin on either side of the cradle that could tilt up to launch the TDRS. This is half as long as this room. It's large, not quite as long as this room, say eight feet long, something on that order, and it's got the two trunnion pins that the longeron latches grab onto. At the middle of each of these things there's a pivot point. That's where the pivot point of the cradle sits. It's a big structure, and it's made of very stocky hefty I-beam metal. The web of the metal is about the thickness of my thumb, and the height of the beam is six or eight inches, and obviously when it's installed in the payload bay both of the trunnion pins are coplanar. They lie on the sill of the Orbiter, and the latches are bolted down around them.

Here I think it was the port spreader bar from the IUS [Inertial Upper Stage] cradle that was lying on the floor. One trunnion pin was on the floor of the hangar, and the other trunnion

pin eight feet or so away needed two four-by-fours to fill the space between the floor and the trunnion pin. This big immense robust piece of metal had just bent, like it reminded me of the way you can take those processed slices of cheese and bend them in a sheet before they crack and break. This thing is just plastically deformed. It didn't seem cracked. It had just plain yielded to like an eight-inch offset across that width. It just spoke volumes about the kind of forces that it had been subjected to when the vehicle came apart.

On the other end of the scale, when we got down into some of the crew module stuff, there's JR's [Judith A. Resnik's] reference data checklist still with the tether attached and pages still there. So here's this paper checklist, is for all intents and purposes intact, with a slightly scuffed cover. This big honking piece of metal is bent eight inches. Just those odd juxtapositions. It was just an important thing to do.

I got involved in little bits of ways on that end of the investigation just because it mattered to me, and so I inserted myself in it. By around the middle of the year, I was pretty busy with the Challenger Center. Trying to immerse myself in that and make some sense out of it. Eighty-six, eight-seven was also a phase of time that I was pretty active in one of the small airplane flying clubs. I was doing a little more little airplane flying than I had done in a while. I think it must have been July of '87 that I—could that be right?—that I pulled together the weeklong meeting out in Tucson [Arizona] where we brought together—this was Challenger Center—where we brought together thirty, thirty-five folks from different spheres of education to try out my initial ideas. We had a couple classroom educators, some curriculum specialists, a couple museum professionals, even a few folks from the publishing world, and we laid out this idea at the top conceptual level. This is what we are conceiving of the Challenger Center. It's going to be simulation-based learning, and it's not going to be a building. It's going to be

multiple locations. What we're thinking of is we'll build a kit that will have a mission control room or area and a simulator room or area. We want you guys to help us understand what the scale, scope, and size those should be.

What we're envisioning is instead of the Challenger Center marauding into your community and hijacking or poaching your donors, Mr. Houston Museum of Science or whoever you are, what we're seeing is you're in your community. You're engaged with your community. You've got relationships with the teachers; you're already valued and known to the funders. We think the Challenger Center should be a platform you can choose to add to what you can serve your community with. We'll be your partners in fundraising and taking it forward.

We had conceived by that time of the network of learning centers, and we'd thought through a fair bit, "What's the value proposition? Why would someone join? Why would you want to join this learning network? What does a science museum in San Diego [California] or Denver [Colorado] get for being in this learning network? Is that robust enough that we could set an annual fee for being in it?" Because that could be a first way to start propelling the Challenger Center forward.

We had again a top-level conceptual working model of all these pieces, and we wanted to just lay it out to them. I deliberately, very consciously, pushed back on the families that we ourselves were not going to stipulate the finer scale details and then just lay it on people. The important thing for us to do was have a clear conceptual model for what does this want to be, and a clear understanding of a core set of characteristics, attributes, and values that the Challenger Center will be known for, and then let these folks fill in how things should work at the operational level.

If they bought into the idea and would subscribe to and adhere to the values, that's the kind of level that you can really generate loyalty at. Then let them build with us the further definition of the details. If we did that, then we would never have to go into another town trying to sell them something that we had made up. We could go from community to community saying, "Your colleagues in another city have detailed this out. You will be able to tailor and customize this range of things to be sure it suits your community." It is in a sense like a franchise model, but it's more like a YMCA [Young Men's Christian Association] model than a McDonalds. With the Y, the logo identity of the Y and its focus on youth, young men or women, Christian values, are invariant, as are some essentials of fiscal stewardship and governance. Those are required of everybody. What the community in Columbus most needs is going to be different than Kansas City [Missouri], Denver, or Abilene [Texas]. So what exactly the Y does in any of those cities may be very very different, but the group identity is common. We didn't enunciate it that way at the time, but it's what it amounted to.

It was a fabulously fun but a very intense period of time of going through all the stuff that June had gotten. Getting acquainted with the Association of Science and Technology Centers. Learning a lot about what is this community or collection of science centers that exist in different cities, and how do they work from a financial model point of view. Is it plausible to imagine that you're going to say, "Why don't you add this to your repertoire, and what kind of funding scale is plausible for that?" Just learn that well enough to have a reasonably feasible idea to set out to them.

The week that we were in Tucson was intense. Anyone who has done meetings like this would probably list a long list of things that I was foolish to do. Happily no one told me how foolish I was. I had come up with this idea. I had designed the meeting, I had just by inquiry

and common sense found a cohort of people that seemed reasonable. We'd written cold letters. Why would you come? Well because it's the *Challenger* families, which was an interesting link. Also we said we'd to pay their expenses. A week of anybody's time, five days is a lot to ask. We got them all to come. We didn't have a lot of money in the bank at the time. It was probably something in the \$50 or \$75,000 range, and this ate up about 75% of that in one chunk. It had better take us somewhere worthwhile.

It was just this amazing combination of designing it, planning it, orchestrating it, doing the logistics, and then facilitating it very intensively the whole way through, because again we really had no staff at the time. Challenger Center was the surviving family members, literally four or five other volunteer folks who were helping set up the 501(c)(3) and figure out some of the initial governance, and me—who had volunteered for none of that but had agreed to spend a goodly year trying to launch something that could become a viable education program. My handshake with June was, by the end of the year if I'm really onto something worthwhile, we should have enough clarity and momentum that we can see a couple of roles to hire for and have a clear scope of things happening. If at the end of the year we don't have that, then I'm barking up the wrong tree or we've got to reset on what the core ideas are, and/or you should ask someone else to take a shot at it. So that's our deal. We got something going, and we actually need to start hiring at the end of the year, or you should ask me to rip it all up and try again or step aside. Fair? That's fair. That was it.

By the end of the year we had Houston Museum of Natural Science [Texas] committed. They came out to the Tucson event. It was incredibly intense. Lots of people were trying to sell June buildings, because I think they figured this poor lady's going to get to build something, and boy, what she ought to want to build is the building I've always wanted to design. She had

dozens at least of unsolicited architectural proposals for fabulous futuristic neat buildings that could be your educational center. No one had thought at all about what's anybody doing in there.

ROSS-NAZZAL: Or funding or anything like that.

SULLIVAN: Or funding, and one of the key things that June said over and over again that really drove my thinking was she keeps saying she wants children across the entire nation and maybe around the world to be influenced by whatever this thing is. No one building does that. A building doesn't do that. So what might? That's circuitously how I landed on well, something that's in their neighborhood much nearer to them and very explicitly part of a fabric that links back to this crew. I'm holding on to my thread of that fabric, and it's in my neighborhood. That's where that idea came from.

The Tucson event included one of the architects who was the leading contenders at the time. My instruction to him was you have a building idea, and there is a program idea. We're going to explore and flesh out the program idea for the first three, three and a half days of this. At that point, end of day four or thereabouts, I'm going to invite you to get up and tell them about your original concept of the building. Here's what you want to do: tell them your original concept of the building, recap all the things you've heard, and give them a sense of how what they've arrived at will influence, change, and shape what you now envision for the building.

He basically got up and said, "Here's the wonderful building I'm going to build." It's like he hadn't heard anything. There was a near-mutiny of some of the best players in the group. I ran across the site and grabbed June. I said, "You have to be here for this moment." I walked into the room with her and couple of the mutineers in tow, stopped the proceedings cold and

said, “The perception in the audience is that you either haven't heard or haven't taken aboard almost any of the features of the program that have been described here.” We thrashed that out.

The upshot of the Tucson meeting was the architect was fired, and the Houston Museum of Natural Science put their hand in the air and said, “We think this will work, and we'll be first.” That was not the museum director, it was their space and science education program gal Carolyn [Sumners] who saw that we had already jumped into this with both feet and just jumped off the cliff with us. They launched the first one not more than about a year later. So my '86, '87 were full of this.

Of course, Hubble stuff was interlaced in there as we continued with that engineering work. Somewhere around mid '87, I was assigned to be CapCom for what was then STS-26, and being teed up for a sometime-in-'88 flight date, which ended up being September. Now I could see another little path back to flight ops. We knew roughly where Hubble was going to be, it seemed, so we were starting to lay back out a flow of activities aimed towards a launch slot.

The other big evolution through that timeframe had to do with the military. Some months after the accident, when the manifest was being completely rethought and the national policy forcing the Air Force to put all their payloads on the Shuttle, was put back into play. Lots of different bits of rumor and report would flow around the office.

At one point, one of the rumors that flowed through the office was that the commercial guys were going to bail off the manifest. They were just going to take their marbles and go somewhere else, leaving the Shuttle to fly just military cargoes and NASA science cargoes. If you looked at the manifest before the accident, a large number of the slots were commercial. So assume those all go away. For starters, there are a lot fewer flights left. Some goodly percentage

of those left at the time, would be military, and Headquarters was going to decree that only commissioned military officer astronauts would fly on military flights.

That meant all the civilian astronauts were going to be flying on not too doggone many flights. There was a little confab among some of the gals in the office saying, "This isn't going to be very good. We're going to only have access to a tiny little percentage of flights on the manifest." We had an anguished and somewhat angry debate about that. Somebody said in that debate, "Well, maybe what we ought to do is we ought to all go off and get commissions as reserve officers, or tell them we're going to do that. Because one way to push back on Headquarters about this would be to let it be publicly known that all the civilian astronauts are going off to get military commissions because otherwise there's no viable flight opportunity in the nation's civilian space program." That wouldn't fly too well. So that went by as things do in coffee klatch conversations.

I remember thinking that this construct didn't seem very likely to yield the result they were thinking of. The person who mentioned it said, I think we should join the Army Reserve, and I thought, "Who would want to be in the Army?" Somewhere that started in my mind a thought. I had episodically looked into joining the US Navy Reserve. This goes all the way back to being in graduate school and encountering USNS (United States Naval Ships), research ships in interesting ports like Reykjavik, Iceland. I also knew some of the civilian oceanographers that worked for Oceanography of the Navy and the Office of Naval Research, and read their papers during grad [graduate] school. They clearly were doing interesting work.

When I would meet these ships in port, they would usually not invite us aboard and not say a whole lot about what they were doing. They must be doing something interesting. Guys we met in Reykjavik had started at Rota, Spain, and they were now in Iceland, and those are neat

parts of the world. “Who are these guys that get to sail around this part of the world, and what are they doing?” I was vaguely annoyed at why they wouldn’t or couldn’t tell me anything about it.

I had inquired a number of times from say 1973 forward about how oceanography works in the Navy, and whether I should join the Reserves to have more chances to go to sea. I kept being told that I didn't want to get in the Navy, that there was really no workable niche for a female PhD scientist. That I'd get categorized into secretary or yeoman or something that wouldn't make good use of my talents and you wouldn't be any fun.

Then during the '70s, the Navy organized a technical specialty called oceanographer. There now was a distinct professional community that focused on geology and geophysics: waves, tides, currents, sound propagation in the sea, and aviation weather. Basically everything about environmental forecasting was lumped into oceanographer. Some years later, they also organized a distinct reserve component for that. A lot of that had happened after I had gotten to NASA. Once I discovered this, it triggered a thorough re-think of the Navy Reserve prospect. I thought, “Well, it's been a long time since I've pulled that string. I wonder if the answer is still the same, that there's no meaningful way to be involved. Maybe I ought to look into that.”

Some day after that, I'm at my desk in the office I share with Bruce McCandless, and we're both doing desk chores. I remember he's standing up and he's opening his mail. I glance over at him, and it occurs to me, “Oh, that's right, I know a way I could look into this.” I think I had vaguely been fretting a bit about, “I wonder how I test whether the answer to this question is the same that it always was.” This day, I realize that Bruce, then the senior naval officer of the United States astronaut corps, can probably point me in the right direction. So I gave him a short recap of it all, ending with, “How would you suggest I re-investigate whether it's still the case

that there's no viable meaningful worthwhile way for me to do this, or whether I was just getting a standard perfunctory answer and there's a different answer now?"

Honest to gosh he looked at me over his bi-focals—he always wore his glasses down on his nose—and stopped what he was doing. Still poised in mid-letter opening as I finish my question. He looks at me and he says—on this random day that I happen to remember to ask him—he says, “Well, I'm having lunch tomorrow with the secretary of the navy. Would you like me to ask him?” I said, “Well sure, why not? That wasn't quite the pathway I had in mind, but since you mention it, go ahead.” It was just crazy.

He did, and that was Secretary [John F.] Lehman. Secretary Lehman in particular, maybe a bit because of his own background, believed that not everyone whose technical skills you would like in the Navy decided when they're eighteen or twenty to go into the Navy, and especially people in medicine, nursing, dentistry, oceanography, some of the very deep technical specialties. You're not going to get all the good folks when they're seventeen or eighteen, because they're just not going to have made that decision. The rate of technology and skill advance in the outside world in some of those fields is going to be different, sometimes faster, than it is inside the Navy. So you ought to be sure there is a pathway for those refreshed skills to serve the Navy, starting at a different entry point. He was quite amenable to the idea of direct commissions for people who'd gone into certain technical fields in particular, and who in their later twenties or thirties said, “Hey, I'd like to offer this up to help the Navy or my country, can I do that?”

He was receptive to the idea, and he had an executive assistant serving him at the time, Joseph Prueher, Captain Prueher. Poor Joe Prueher, I can just imagine how this went. Gets this

assignment after Captain McCandless's lunch with the secretary. "There's this girl down in Houston who thinks she ought to be a naval officer. Go find out what the hell's going on."

It was a very long time coming. I was just about to pass the maximum commissioning age. In fact, by the time it all unfolded, I was in fact some six months past the age thirty-five, maximum commissioning age. That alone would require a waiver by the secretary of the navy. So there was going to be nothing routine about this process. It seemed that there was strong interest quite quickly, probably at the secretary of the navy level, to give me a good look. My background was certainly relevant. I started doing my own research on how is the Navy Reserve was structured. What pathways exist? There is oceanography, is there anything else? Just trying to be thorough, build my own knowledge base and be able to review decisions and suggestions they made and advocate for my own course of action. It came down to the intel [intelligence] community versus the oceanography community. Those were the two that made sense.

It finally all cycled its way through, and I actually was commissioned. I guess the Navy evaluation process looked at where you were in your career. What degrees you had and what relevant operating experience. The Navy equated that to some rank, especially for MDs and other doctoral level folks, so that they did not come in as an ensign. So the long and the short of all of that processing was that I was granted a commission, and they granted me the rank of lieutenant commander, which is equal to a major in the other services. The simple way to sign in is to drive to an office in Houston, put your hand up, and swear the oath. Presto, you're a navy reserve officer. I thought, "Yes, but I would really rather do something a little different."

So I called up Admiral Dick [Richard H.] Truly, who was the NASA administrator at the time, told him what was happening, and asked if he would commission me. I started looking into

uniforms, figured out how all that worked, got myself over to Pensacola [Florida] a couple times, and got fitted for service dress blue uniform, striped for lieutenant commander. I was commissioned in Admiral Truly's office with him in his admiral's stripes. A young son of some very dear friends of mine in Houston was at the Naval Academy [Annapolis, Maryland] at the time as a midshipman fourth class, a plebe. I wangled him permission to come up to Washington and be there for the commissioning, and took along a silver dollar that had been his grandfather's. One of the neat traditions around commissioning is that you give a silver dollar to the first person who owes you a salute once you've been commissioned.

In officer candidate school that's often the same drill sergeant that was just beating on you two seconds ago. As soon as you say, "So help me God," you outrank the drill sergeant. Now, you have not outranked the drill sergeant at all until that moment but right then you do. So when the drill sergeant comes out after the commissioning, all the new officers are still conditioned to snap to attention and hold their salutes till he salutes back. This time, he's supposed to salute first and not drop his salute until you're done. It's one of the fun things at ROTC [Reserve Officers' Training Corps] and other commissions to watch all these former midshipmen realize, "Oh, that's right, I'm now the senior person here," and start adapting.

You give the person who tosses you your first salute a silver dollar; that is the tradition. So I got Travis Beal's grandfather's silver dollar and arranged for him to go out the door ahead of the rest of our party so that when we came out he had to salute. Flipped the coin way up in the air and gave him his grandfather's silver dollar. It was a really neat moment. So, joining the Navy was the other notable thing that I did in the middle of the accident downtime—signed myself up to this whole other big bureaucracy and service commitment. My dad thought I was crazy. It was great fun.

ROSS-NAZZAL: Were you the only mission specialist that ended up actually following that path?

SULLIVAN: Jim [James P.] Bagian path was concurrent with mine. Jim, medical doctor, very outdoors, active, athletic kind of guy. He had gotten intrigued with the combat search and rescue forces of the Air Force Reserve. He started pursuing an Air Force Reserve commission right around the same time. We both got in. He wangled to get in one grade higher than me, as a lieutenant colonel. I figured lieutenant commander was probably about as far as the Navy was going to go on our side. More importantly, when I looked at the job structures within the Navy Reserve for oceanography officers, that's the highest I would have wanted to be.

The Navy Reserve community at its greatest end strength only had about six captains' billets and maybe eighteen or twenty commander billets, which are the equivalent to the rank Jim went in at. Lieutenant commander was where the broadest mix of the really good junior officer command jobs were in the Navy. There was a lot of running room there. You could be OIC (officer in charge) of a detachment, you could be XO in all kinds of different units, or you could be technical officer and manage R&D [Research and Development] portfolios. I figured I didn't want to quickly get to a point where there were only six jobs in the whole country, and I would have to bounce from one to the other. I had a great time.

I got out to sea. That's one of the places where the 41G radar experience came back around, because I spent almost all of my time as a lieutenant commander working with Office of Naval Research research and technology transfer program. We were some of the shoe leather that would take what's happening in the labs, go out to fleet units, and be sure they knew about different new capabilities that are in the lab that haven't made it out to the fleet as a full up

system yet. But, you can get a prototype out to here. You'd go both ways. Here are the problems they're working on in Med (Mediterranean). Here are the things that they can't get, or that they're struggling with, in terms of antisubmarine warfare. How do we connect this back to the lab work? Maybe some new sound propagation model that they're still testing in the lab could solve some of the problems that the guys in the fleet are working with. Let's take one of these things out to the Med and do a test on it and see if we can't accelerate the transfer of this technology out to the fleet. You did a lot of cool stuff like that.

Six weeks after I was commissioned, I was briefing the Commander in Chief US Naval Forces Europe on environmental conditions across the North Atlantic and into the Mediterranean. Better learn fast. Does he know I only just learned how to salute?

ROSS-NAZZAL: Did you have to go through any sort of basic training?

SULLIVAN: Well, you are supposed to go through a two-week reserve school called DCO school (Direct Commission Officer school). The facetious gouge on DCO school is that it's knife and fork school. It's a comfy school down in Pensacola for the medical doctors who have been recruited and have never put on a Navy uniform in their life. Don't know where any of the doodads go, know none of the protocol nothing. It literally teaches you, "The insignia goes on your collar here" and this and that and the other. This insignia means you salute him, and that insignia means he salutes you. I informed myself. I knew that that's supposed to be the first square that you check off on the list.

[S.] Dave [David] Griggs had helped link me up to one of the reserve units that did the ONR [Office of Naval Research] tech transfer stuff. Pete [Peter B.] McWhite, the captain

commanding that unit was at the commissioning, so we started our relationship quickly. I got up to Washington DC for my first drill weekend and found the piece of paper used to request the two-week summer-training period and filled in the data for DCO school down in Pensacola. I took it to Pete for signature.

He ripped them up the form right in front of me. He was great. He was just this great guy. He said, "No, you don't. You can figure out how to get yourself commissioned by a two-star admiral already properly done out in lieutenant commander service dress blues, there's nothing they're going to teach you at Pensacola. You're going to the Mediterranean. There's a fabulous young oceanographer over there, Lieutenant Commander Cindy [Cynthia P.] Dillon. She's brilliant. She's in your specialty. She'll probably only be there this year and next. You can't get better training than go to work in the Med with Cindy Dillon for two summers, so forget that. Go fill out paperwork for CTF-66 in Naples."

"But won't the system check for this training?"

"No, the system is like never going to check that you didn't go to DCO school. Bring me the other papers." So I did. I was over in Naples [Italy] about six weeks later, working for Cindy Dillon.

ROSS-NAZZAL: Are you still involved?

SULLIVAN: I actually just got out earlier this year, as a captain. The whole Reserve and Guard force structure and philosophy is being transformed by Afghanistan and Iraq. The number of captain slots had winnowed to about three. There are no captain's billet here in Columbus, so I had put myself in a nonpay status to give myself flexibility. I instructed and did career advising

for ROTC here on campus for a number of years. Then the civilian job became even more intense. I put myself in an even less active category, the Inactive Ready Reserve, and as the tail end of my COSI [Center of Science and Industry, Columbus, Ohio] time and this job at the university came up, it became clear my life was headed in a different direction.

The Navy Reserve is getting back into active drilling. Number one, the active drilling is all miles away, Washington at best. It's no longer the case that you can really be very effective as a reservist by going to a base somewhere with just a group of reservists and spending your Saturday and Sunday together. Drills are more and more integrated, almost like consulting, and they augment into the active duty work activities, and that tends to mean be at ONR or operational commands during the workweek. They adjusted things so that you can group together some of your reserve days and spend five days in a block on drill, but then you need to be able to take five days from your civilian job. It's pretty hard to do when you're the CEO [Chief Executive Officer] of a small cash-based business, with the kind of civic leadership role that nonprofit executives have.

Those two strands just kept moving further apart. As long as the support for the ROTC unit here was a viable path, things worked well. The last year we were getting to a point where the Navy was trying to pull back billets. If you're in a nonpay status or the Inactive Ready Reserve, they started to say, "I either need you getting back into one of these billets, getting active again, or I need your billet back to transform into one that we can use to send someone out into theater or to backfill somebody who's been shipped overseas." I got out in December or early January, so just a couple months shy of the twenty-year point. Honorably discharged.

ROSS-NAZZAL: What impact do you think that the *Challenger* accident had on the astronaut corps? It's always something that I like to ask everybody.

SULLIVAN: Oh, countless impacts, just countless impacts. I think in some ways it transformed and reinforced a kind of group identity. I think those were our guys. They were everybody's guys that got lost in a lot of ways, but it's important to mention, I think, that there was a sense of those are our guys that got lost in that one. It seemed to be because of the flawed decision-making in other parts of the agency and by other entities. There was a lot of us-and-them mentality there. It spawned a fairly big us-them dynamic between JSC and Marshall [Space Flight Center, Huntsville, Alabama] for a while. Your guys made the dumb decisions about O-rings, didn't tell people, and were not forthcoming. You are the turkeys that caused all of this. It did that.

I think it fired some more resolve in lots of us that you've got to get back flying again. It is a very sad thing for anybody to lose their life in pursuit of something that they're doing, especially something where they're serving their nation. But if the real purpose and commitment of the country is so thin that you'll quit that enterprise just because you suffered a very sad loss, then it suggests that what you were doing must not have been all that important to the country after all, because we just decide to quit doing it instead of pressing on through a moment of grief and hardship. I think to some degree it fired our resolve that we're going to get back to flying. We owe it to them. It is very sad that they died, but they didn't die in vain, and this will go on. We'll learn the lessons that are to be learned technically and organizationally, and get better because of that, get better for that. It did a lot of those things.

I think it sharpened the focus within the astronaut corps. There's a piece of this that was always present. You know it if you're flying airplanes. You fly all the time with the mentality that this nice helpful voice in your headset from air traffic control [ATC] is actually trying to kill you. The ATC can sometimes be very helpful, however, but he doesn't know where you are. He doesn't really know what's going on in your airplane; he's not responsible for your airplane. He's telling you to do things to neaten up his world and make it work better. Sometimes that's fine, and you can accommodate what he'd like you to do. But you can't take the voice of the controller as your dad or some higher authority telling you what you must do. It's just a voice stating some things that would be nice to get done.

You've always got to be thinking. You've got to realize sometimes what he wants you to do is going to be exactly not what you ought to do with your airplane, and you've got to stand up for that. The sharp and slightly joking way of putting that is yes, you got to love those guys, except that you have to remember they're always trying to kill you. Don't get complacent about this. Although you lived with that and knew that on a lot of levels, I think some of that same mindset was sharpened in terms of scrutinizing things within the agency and across different entities in the agency.

ROSS-NAZZAL: What was the mood like at the Center until STS-26 actually lifted off?

SULLIVAN: JSC went through a number of different phases. Deeply wounded and fiercely angry is certainly what the mood was for part of the time. I remember Jim [James C.] Fletcher, the administrator at the time, came out to the Center. I'm sure it was meant to be the boss coming down to try to stabilize the troops, do a bit of consoling and encouraging. Give them some

confidence, steady the ship, and get them back to thinking ahead and thinking constructively. There was an all-hands or whoever-wants-to-come session in the auditorium in Building 2, and he made some remarks that were not particularly memorable to me.

Then he agreed to take some questions, and almost the first question that was asked—not by an astronaut—was basically about crew safety and Marshall. A number of Space Station design responsibilities had been allocated among the Centers in the time between the accident and this assembly. Marshall had been given the role of crew modules, crew equipment, and crew habitation, items having to do with the shelter, safety and life support of human beings on the Station. That decision disgusted and enraged a lot of people at the Space Center in Houston. It boiled down to, “These are the idiots that just killed our guys. How do you give them this responsibility? They just killed a crew. How do you do this? You can't be serious.” That big burst of anger. “These guys just killed a crew, our guys, and how can you possibly give them this responsibility?” was basically the punch line of this question. It was put pretty fiercely, not uncivilly but sternly, and very directly. No nice “dear Mr. Administrator” embroidery. It was pretty much “you have got to be kidding me.”

I thought, “If he has the least bit of an answer, he has a chance to really take this crowd and move us along a little bit.” Maybe even didn't have an answer. I don't know what triggered him, but his response was basically a summary dismissal of the question and a retort that this is two-year-old-ish behavior. Essentially “I'm not going to tolerate such things,” and he walked off the stage.

The whole room was stunned. “What was that? This is our leadership?” It spun up a whole swirl of anger, dismay, concern, and wounded grieving pride around issues of leadership, loyalty, and identity, of Marshall versus Johnson, a lot aimed at the guys at Headquarters.

“You’ve got to be kidding....” Lots of that emotion for some number of months. Different for different people, probably different organizations. I remember a fair bit of that for a goodly number of months. We had a Hubble meeting not long after the accident up at Huntsville. One of the things that we were reviewing was a set of crew walkdown items that Bruce and I had identified while looking at the telescope instruments from point of view of EVA: fixtures, equipment, techniques and potential hazards. You're asking questions like, are there any sharp edges the way you've manufactured this, sharp edges that could snag a suit? Are there any safety hazards?

The wide field planetary camera [WFPC] is this big odd-shaped trapezoidal box that slides in toward the central axis of the telescope. A small mirror sticks out of its nose into the light path, extending out from the boxy bit of the camera, on a small arm that's about eight or ten inches long and made of a fine scale truss of metal. That mirror assembly and the way the mirror attaches does indeed have a couple sharp edges to it, but there isn't and wasn't really much they were going to do about it. That was flagged as a hazard as we did a walkdown. It was carried as an open item. You're either going to come up with a modification to the bits that are hazardous, or you're going to try to convince us that there's some shield or crew protection aid that we can work into the procedures that will make sure the camera doesn't damage a suit and the astronaut doesn't damage the camera.

We're back up at Huntsville, and we're reviewing a whole list of items like that. That one was flagged as a safety item because of the suit hazard. We're going through this list, and the WFPC pickoff mirror isn't on the list of open items. I asked. I pointed that out and asked where whether it had been resolved. The answer was that they had not fixed it, but that someone had decided to take it off of this list and put it on some other list as an administrative convenience.

That's fine, that's fair, but it was at this table that we identified it. It can't come off this list until an answer has come back to this table. That's not how they thought about it. If they transferred it to someone else to work on it, they erased it from the list where it had first been identified. Well, this was an element of exactly the same administrative mismanagement of an anomaly that was part of the O-ring problem. At the top level of those sitting in the launch control center, they are obliged to report any open items. Their guy could sit there and say, "I don't have any open items." He had given them all to somebody else, but they were still open. They weren't fixed, but weren't not on his list. So his list looks good. They were doing this same thing. I recognized it as the same blind spot and the same behavior. I just started spinning up.

I was still very angry, and they were not seeing this. It was difficult to try to get them to recognize it. I thought, "You guys can't even do a mirror right. It's a good thing we're not giving you anything more." I finally got out of the room till I could calm down. There was that kind of anger certainly on my part for a time, and I think lots of folks for a period of time. As work picked up, as momentum picked up, as a new manifest was there, things came back around. Over time everyone moves past that and starts getting back into doing constructive things. It felt really really good to get people in orbit again.

I had the very fun job on STS-26 of being the planning shift CapCom, which covers the time when the crew is asleep. That was a single shift crew, so they all are awake and working for a certain number of hours of the day and then they all go into a sleep period at the same time. During that sleep period, the shift on the ground at mission control is taking stock of how the day's flight plan went. What got done and what didn't? What happened—what anomalies, what updates or engineering updates are due to the crew? You're basically reviewing the plan for tomorrow, thinking about what things for tomorrow need to be changed, preparing all the

updates on propellants and consumables, and monitoring the vehicle while they're asleep so that somebody is actively keeping track of anything happening while the crew is asleep. The substantive product of that shift is the whole packet of updates that is uplinked to the vehicle in time for crew wakes up in the morning. Think of it as the morning mail. It is everything from a little snippet of news from the families, sports scores and some highlights from Earth news, to updates on the vehicle, the anomaly log, your flight plan, and feedback from the science teams. It's all that kind of stuff. It's the kickoff your day. It's your morning newspaper as you start your day on the spacecraft.

The planning shift assembles this package and uplinks it to the vehicle. That's the technical part of the job. The fun part—the “style score,” if you will—is that the planning shift CapCom gets to pick the wakeup music. I was feeling pretty jazzed that after a very long time we were going to have a Space Shuttle and an American crew back in orbit. Flight day two was going to come along, and I was going to get to wake them up. A couple months before we were going to fly I actually started thinking about, “This is not the Neil Armstrong moment, but this is still a pretty big neat moment. What are you going to say, what are you going to do? *Discovery*, Houston in the morning standing by,” seemed a little flat for how I was going to feel anyway. What's the music going to be? I started playing tunes and thinking about that.

At some point I realized that I was going to feel like shouting out loud on air-to-ground that morning. Letting loose with a really exuberant, “Gooooood morning, *Discovery!*” Oh, sure. Like you're going to do that in mission control, with national TV looking on. Besides it's been done: that's *Good Morning, Vietnam*. And then it clicked. I said, “That's right, it is *Good Morning, Vietnam*.” I knew some people who knew some people and made my way to Robin Williams's agent. I painted this backdrop to them and said, “That's really what it ought to be.”

Bless their hearts, they locked Robin Williams in a sound booth and recorded about eighteen variations. They gave him the ship's name and the crew names, their first names. Turns out Robin went to Harvey Mudd College [Claremont, California], which is where Pinky went, so there was this other little association. He just cut loose with a dozen and a half variations on, "Good morning, *Discovery!*" If it was eighteen cuts, I think fifteen of them would have gotten me fired immediately if I'd played them on air-to-ground. But three or four of them were just outrageously amusing.

For a moment they were all over me. "We'll send you the draft of our press release about doing this."

I said, "You do any press, and none of this goes up."

"Oh, we have to tell people."

"No. You do any press whatsoever, and none of this gets used. Don't do any press. If these are played, I guarantee you you'll find that no advance press releases were needed." They relented and just stayed quiet. I said, "By the way, I need the original tape and all copies." I grabbed a hold of all of that.

Now I had the start of the wakeup call. Then I discovered this guy at the Space Center who worked mainly as a guide in Building 9 and did music on the side. He would take published melodies, like Beach Boys tunes or Beatles tunes, and redo the lyrics to suit the space program. They were really clever, idiomatically correct verses. He did some really really great lyrics. That great '60s Motown song "My Girl" has a refrain in it of, "I've got sunshine on a cloudy day with my girl," which came out as, "I have sunrise sixteen times a day in my world." Got the rhythms right, just really brilliant. He did a couple of songs for us that were completely STS-26 specific.

The wakeup music for most of the days in the flight varied. We used Robin Williams more than once. We ran a couple of his calls up. Then we ran this guy's tunes up. I didn't quite anticipate all the consequences. Before long, I found myself taking phone calls from music agents. In particular Willie Nelson's people claimed that Mike [John M.] Lounge was a real Willie Nelson fan. They heard these customized songs going up and so I now have these guys calling me saying, "Willie is really ready to write a custom song for these guys." So I found myself having bizarre, James Bond-like midnight rendezvous in the JSC parking lots to pick up Willie's cassette tapes, in case I would use them.

Marsha [S.] Ivins got that same guy to write some songs for STS-27. By about that time I think the celebrity artists and the music community probably were starting to pepper NASA Headquarters. "I'll write custom music too, if it gets beamed the Space Shuttle." So they shut it down after STS-26. The only nonpublished music that could up air-to-ground would be school choirs and other groups like that. Otherwise it had to be published, normal typical production music. They didn't want to be having to pick entertainers and deal with agents, or they thought we were having too much fun. Some mixture of those two things. It got shut down pretty firmly.

I did love it when the end-of-year news broadcasts that do all the year in review pieces—when they came back to the proud and happy moment of putting the Space Shuttle back into flight. Every one of those summaries opened with Robin Williams and carried our wakeup music as just emblematic of how it felt. I thought, "Well, that's exactly right, that's what I was trying to do." So that was fun. It's one of my favorite color commentary stories.

ROSS-NAZZAL: That's great. You read about a lot of these happenings going on at JSC, but the *Roundups* don't get into a great detail: how it happened and who was involved.

SULLIVAN: Yes, middle of the night rendezvous in the Building 1 parking lot. I felt like I was doing dead drops for the CIA [Central Intelligence Agency] or something.

ROSS-NAZZAL: It's great too, because I just actually talked with Mike Lounge. He did talk about that Willie Nelson song. So it's nice to have the story intersect.

SULLIVAN: The other thing I remember is a couple of the wives, because they thought the tunes were hilarious, and just fabulous, Kathy Covey in particular. We were at, I guess, the postflight party. She comes up to me and says, "So we get these guys, and we get on the plane. We said, 'How'd you like the wakeup music?' and they said, 'Oh yes, that was pretty fun, who was it, that sounded almost like Robin Williams or something.'" They're kidding them. "It was Robin Williams, you turkey. She got Robin Williams!"

ROSS-NAZZAL: You get some special award from the crew?

SULLIVAN: No. I didn't need one. I have the tapes. We had this guy make up one final song. The STS-26 crew was prime crew for an exceedingly long period of time if you think about it, prime crew with all the extra import and spotlight and everything else on them. You need that. You need the icon of the crew that's going to fly again. There's all sorts of right and good reasons for doing that, and they did a great job. But as this rolled further and further on, it also

did start to seem like they were slightly overly enjoying this prime crew status, and making that mistake of thinking that it wasn't actually about the first guys to go fly, it actually was about them personally. Hoot [Robert L.] Gibson and his guys were up next on STS-27. They're a DoD [Department of Defense] flight, so no one knows anything about their cargo. They were going through a protracted period of time feeling that a) we're never going to be prime crew, and b) we're like only right after these guys and we can't get any of the resources we need. They're beginning to take this very personally.

There was a big Challenger Center celebratory event downtown in Houston in early '88 sometime. June persuaded Rick [Frederick H. Hauck] and Dick [Richard O. Covey] to come downtown and be featured. They did this huge melodramatic moment. They took Covey and Hauck below the stage, stood them on risers, and flooded the stage with theatrical fog as Lee Greenwood sang "Proud to Be an American." They're in their tuxes. These risers come up through the floor, and it's like the phoenix up from flame, all of that symbolism. I had stayed away from that event, so was watching it on TV. They almost looked like they were slightly hanging their heads, a bit embarrassed about this whole moment. So this is Saturday night.

Monday morning is the all-astronauts meeting, with all the typical updates from the head office. After that, [Daniel C.] Brandenstein would go to each of the mission commanders in sequence. "You got anything the group needs to know about or an update about what you're doing?" By this time, I've noticed something seems a little odd with the [STS]-27 guys. Hoot and Guy [S. Gardner] are sitting up on the right front part of the room, where they don't normally sit, and they've got their hands at their neck like this through the whole meeting [demonstrates], and that doesn't look at all natural. Something isn't normal.

Brandenstein finishes his stuff and then says, “Okay now,” to the crews, “STS-26,” and Rick says, “No, we don't have anything.” Dan looks across the room and says, “27?” Suddenly this noise starts, and then some music. [Richard M.] Mullane has turned on a fire extinguisher, and CO2 is coming out below their feet. Another crewmember has turned on a boom box, and “Proud to Be an American” is coming up. They've put their hands down by their sides, they're wearing white shirts and black bowties, and as the music goes they rise very stiffly, as if they're levitating themselves from their seats. They rise all the way until they're standing straight and tall. Then Mullane shuts off the boom box, the fire extinguisher goes out, they sit back down and Hoot says calmly, “No, we don't have anything.” It was a bit of a statement.

I got the guy who had written us all of our custom songs to write one more song to the tune of “I'm Proud to Be an American.” The main line went, “I'm proud to be a celebrity standing in the public eye.” It just went on and on and had some lyrics in there explicit to STS-26 and STS-27. I got it all taped up and commandeered the boom box and played it at the STS-26 landing party. What's the worst they can do to me?

ROSS-NAZZAL: I do remember parts of that story from Mike's book, [*Riding Rockets: The Outrageous Tales of a Space Shuttle Astronaut*] I think.

SULLIVAN: Yes, he told some stuff about that.

ROSS-NAZZAL: One thing that I'm interested in. A lot of people that I talk to mention that everybody wanted to be on that flight. Why? People weren't necessarily seeking media attention. But why was it so important to be on that crew?

SULLIVAN: They were eager to go fly. When everything has been so much up for grabs and shuffled around in so many different ways, one thing you knew was that flight's going to go. You had the clearest date, the clearest thing to work to of anyone on any other assignment on the manifest. It wasn't any particular standout cargo, like fabulous EVAs. It was a TDRS satellite. I can't speak to what we all felt. What moved me about that, part of it was we need to get back to flying as soon as possible. I'm eager to go fly again. The part that would have appealed to me would be some sense being able to be, in a different way than any other flight afterwards, actively part of being sure our 51L guys got the salute they deserved and we flew again.

It was more of a link back to the crew you lost and, this is probably more of a reach, but at least as a broad metaphor it maybe is a bit like the big but sad honor of being asked to be a pallbearer or to give a eulogy or to give the speech at a one-year anniversary of somebody's memorial service. It's not a role you ever really wanted. You didn't want to be at that moment, but the funeral service has to happen and you have to do right by these people. To be asked, to be given the opportunity to be the person who stands up in such a role and does right by that moment, in honor of those people is a tough and sad honor, but it's something you would do for people that you respected and cared about. So maybe something like that.

ROSS-NAZZAL: How did the Astronaut Office change? I know John Young left as chief and was replaced by Dan Brandenstein. Then George [W.S.] Abbey of course left, and he's replaced by Don [Donald R.] Puddy. How did those changes in leadership affect the office if at all?

SULLIVAN: I think those two changes in particular did of course affect the office, if for no other reason than those two guys had been in their seats for so long and so much habit and culture and rumor and myth had built up around them. When you take those two particulars out and put two other people, you still have a seat called head of the Astronaut Office. You have a position that is head of Flight Crew Operations. When you've had two incumbents for a very long time, and two such iconic and each in their way charismatic, not the stereotypical meaning of that word in every degree, but they both are in various ways charismatic icons in that role. When you shift it, the whole organization experiences a learning curve that boils down to relearning, remapping, remaking sense of what aspects I saw and experienced before actually are about the nature of the pressures, the challenges, and the responsibilities of that position.

They were not maybe as much ever about the individual who was in it, but I always melded those two things together. Now you're going to see Don Puddy serving in the seat that was George. You're going to get a remapping of what pieces that you conflated with George in that role are more intrinsic to the internal dynamics of the Space Center and the puts, takes, pushes, and shoves between Mission Ops, Flight Ops, Headquarters, and Engineering. Some of what you saw during George's tenure you're going to see over and over in largely the same form under anybody's tenure. It's intrinsic to the role and its inherent tensions. Some parts are particular to how George did it or to how Don did it or how anybody else did.

For our class, for us, we had never seen any of those changes. We never saw the Astronaut Office functioning when it was led by Deke [Donald K. Slayton] or Alan [Shepard]. It was just saw John, and we just saw George. This was our first transition and our first experience with how does the organization behave and how does the leader behave when the leader isn't the guy we knew before. It's now someone new. In any organization, when you make changes in

pivotal seats like that, it's inherently a moment both of some anxiety and uncertainty and some anticipation and opportunity.

Both of those are present simultaneously in different dimensions and different people. There may be folks who felt well-served, comfortable, and getting great deals from the guy who was there. Their patron has just left, and they may feel discomfort. The guys that always felt sidelined, underrespected, not appreciated, and never get a good deal, he's figuring "finally my time has come." The reality is probably going to end up being somewhere in between. You maybe were never quite as favored as you thought. You were maybe never quite as dissed as you thought. All of that comes into play again. A collective learning curve is happening and an individual curve for each of the members of the organization. All that's happening at the same time.

ROSS-NAZZAL: After the flight of STS-26, did you start training then for your next mission?

SULLIVAN: I stayed on as CapCom for [STS]-27 and 28. Then pulled back off of that, and I think right around the 28 timeframe the rest of the STS-31 crew was assigned: Charlie [Charles F. Bolden] and Loren [J. Shriver] and Steve [Steven A. Hawley]. It's now 1989. Now we knew we were going to launch sometime in '90. So now you're walking through a more conventional nine-to-ten-month syllabus of forging a crew together and doing the integrated sims, which were pretty complicated lash-ups.

You've got Hubble control at Goddard [Space Flight Center, Greenbelt, Maryland]; you've got the guys at Marshall who had done Hubble engineering and tool design for a number of years. The servicing responsibility had already been handed over to Goddard, but you had

vestiges of expertise and data still a bit scattered between those two places. As soon as Steve pulls the trigger and opens the snares on the RMS, they've got the telescope, and they're coming up on their own learning curve. How do you actually fly this vehicle? We had European science and technology guys over on the ESA [European Space Agency] side of things, and the solar arrays were British. There was also foreign participation in a number of the instruments.

It was a pretty complicated lash-up, and you're bringing two rather different cultures together: the basic Shuttle, a culture very grounded in engineering and Flight Ops, meeting more of a spacecraft science kind of culture, attuned towards a vehicle that's nice and stable in orbit. They're preparing for fairly slowly evolving things called astronomical observations. Except for this magic moment when you're hooked together on the Shuttle and then you release it, and at that point we guys on the Shuttle need the composure and bit of patience to hear and understand the science guys, and the science guys need to be ready for the quick pace of events that happens right at the deploy moment. All that needed to be pulled together pretty carefully.

By early '89, we were beginning to march through. I hadn't flown since '84, it's now '89, so I wasn't current in any training certifications. The way the building blocks of crew training go, every course on a flight syllabus has essentially a certificate of validity. If you come back on a second flight within a year or two, the whole first tranche of basic building block will still current, so you can jump into the pipeline somewhere downstream. If you haven't flown in a much longer period of time, we're not going to take that for granted. You're at least going to make a quick pass through that first level of stuff and be sure you haven't lost any of that. So we had to renegotiate that, where we all were going to come together in the pipeline. Steve had flown in January of '86, right before the accident, so he was more current than some of the rest of us. All that had to get sorted out— just on the basic vehicle stuff, as well as the Hubble models

and the RMS integration—so that you actually could do the fidelity simulations that will let you shake out all these organization-to-organization issues.

ROSS-NAZZAL: Had training changed much since you flew?

SULLIVAN: In broad outline, it had not changed all that much. There was beginning to be a lot of work that I think really made even better use in the '92 and onward timeframe of computer-based training. When we came aboard you could sit at your desk and study a workbook, but there were so few procedure trainers or part-task trainers where you could actually sit in a cockpit and flip switches to really get yourself familiar with every step in the checklist. There were a lot of us, very few simulators and six crews of folks in line in front of us. We did most of our very early “how does this work” stuff by reading through a checklist and looking at drawings, not sitting in a simulator where we could build out motor patterns. Over time, there've been better desktop computer simulators and other things brought into play, so that entry-level rookie-level astronauts have more technical support for that front-end training than I recall us having. In terms of actual flight-specific syllabus, that had really not changed that much.

The big change in the Shuttle mission simulators was back from the old physical model board. For STS-1, when John and Crip practiced landings, a camera was actually physically moving across a model railroad environment that filled a whole large wall. Even by the time we came along, the scenes you saw out the windows were computer-generated. It was pretty familiar. It was strikingly familiar when the engines cut off, and we hit orbit on STS-31. It had been five and a half years since I'd been in orbit. As soon as we hit zero G, it was like waking up on flight day twelve or something. It felt so completely familiar, and I just jumped right back

into it. There's some kind of very intriguing motor and psychological memory that something so rare—eight days' worth of such a rare and novel experience five and a half years before—just seems to click right back into play when you get there again. It's pretty remarkable.

ROSS-NAZZAL: Tell me about the crew relationship. Initially John Young was scheduled to be commander of this mission, is that correct?

SULLIVAN: Hey, I think you're right. But I think that was all while I was buried in doing CapCom and working Hubble EVA preparations. I didn't track that story. Loren probably tracked that story carefully. So what was the story? I forget why John got bounced or pulled himself off.

ROSS-NAZZAL: Steve Hawley mentioned it to us, but not in depth.

SULLIVAN: Steve was always much more closely attuned to those sorts of things. Again, as a guy who's going to be an MS [mission specialist]-2 [the flight engineer], his triangle of interactions as an MS-2 was closely tied to the commander and the PLT [pilot]. “Who am I going to be MS-2 for?” would be a big question in his mind. My triangle of interaction was my EVA buddy in the payload bay and our IV [Intra-vehicular] guy inside. So they'll give us some front seaters, the boss will be assigned, we'll all work for the boss.

ROSS-NAZZAL: Tell me about the crew with Loren, Charlie, Steve, and Bruce.

SULLIVAN: Well, it was very interesting crew. All of us had flown once, but none of us had flown together before. Bruce and I at this point had been working together a long time, but in engineering validation mode, which is a very different thing than the really fine meshing and close coordination—developing the smooth choreography and the clarity of communications—that you strive for as a flight crew. When you're going to be doing events at 17,500 miles an hour, things step up a little bit. It was a pretty easygoing crew; it was a fun crew. Loren's a sharp but delightfully laidback commander. Charlie, I've loved Charlie Bolden from the beginning. He's just a delight, very approachable, a real mentor, a leader of people. Not that Loren isn't, but I've always felt a special rapport with Charlie. And then Steve, also a classmate, smart as a whip, with a photographic memory, who was our arm operator.

Bruce and I had, in a sense, procedures and flow and a habit pattern built around the EVA, and now we need to embed that in the broader flow of events and the choreography of the flight. For the deploy mission, there isn't a planned EVA. The real fitting together of jigsaw puzzle pieces that we needed to sort out was around what would happen if any of the key mechanical devices—umbilical plate, solar arrays, high gain antennas, and aperture door—didn't release or deploy successfully, and how we'd handle the EVA backup scenario. If one of them doesn't work correctly after we've pulled electrical power from the vehicle, when there's a limited amount of battery time to use up, then we have to get out on EVA really fast.

From cutting off ship's power through the Orbiter until drawing power through the telescope's own solar arrays, we had a fixed maximum amount of time; on the order of a couple of hours, not terribly long. So the sequence was, Steve grabs the telescope, then you undo the trunnion pins, so now you know the arm is working; the trunnion pins have released. Now you pull the umbilical cord, last thing. You want to lift the telescope over your head, unfold all of the

arms and legs quickly and, at the correct time with lighting and communications, release it and back away. That's the smooth and easy game plan.

The interval of time between pulling the Orbiter power off and letting it go is when you needed to be spring-loaded for Bruce and me to get out in the payload bay with wrenches and crank something open if it didn't work. The complex crew timeline piece that we had to put together, in addition to just the RMS timeline, was how do we compress the time it takes to get crew members out into the payload bay. The answer basically was, we are going to lower the cabin pressure the night before deployment, as if we intended to do an EVA. We're also going to do all of the EVA equipment checks the day before. So we're going to do flight day one as if we're planning to do a spacewalk the next day. On deploy day Bruce and I are going to go through all of the EVA procedures just as if we're going to do an EVA that day, but we're going to stop at the point where we have our cooling garments on, the suits are in the airlock, all ready to go and the gear is all checked. We'll also take our daily aspirin to promote the release of nitrogen from the bloodstream during decompression to the spacesuit environment. We've had overnight at 10.2 psi to prevent the bends, and we're in our cooling garments.

Then we're going to pause the EVA timeline and go into the telescope deploy timeline. So if Bruce and I needed to hop outside, we've chopped a little more than half off the timeline. What's left is to button up the suit, breathe forty minutes of pure oxygen, close the hatch, depress, get outside. The thing you can't change there is the forty minutes of prebreathe, to make sure you wash more nitrogen out of your body. You're about an hour and a half, maybe two, away from getting outside, which is about half of the normal EVA day timeline.

We had that sorted out. That means that Steve is going to be prime on the arm, Charlie is going to back him up, Loren is looking after the Orbiter. You really can't script Bruce or me into

the deployment timeline in a key role, because on a moment's notice we may have to bail out. In fact, Charlie may have to bail out and come help us get ready. That created another little loop, because Charlie is normally going to back up Steve on the arm. So Loren also wants to be just about as conversant, because he may end up backing up Steve if Charlie's down helping us. As we went through all of that I appointed myself as photo guru. I'm the camera fanatic I guess anyway of the group, so I jumped on that. "You guys can focus on the deploy ops, and I'll do the photography unless or until we get yanked out of there, and then someone else can pick it up."

I had a ball through all the predeploy and the early stages of deployment up until the solar array jam. You want to wallpaper the telescope with photos. You want to be sure that the telescope team on the ground has an "as it was deployed it looked like this" picture of virtually every key device and mechanism and bit of acreage on the telescope. You want to get the *Aviation Week* cover shot. You want to get the marketing and PR shots. I just had a ball, with all the cameras clustered up around me by the windows—a great old time. Then of course the solar array sticks.

We probably stuck around on the flight deck for about three sentences worth of conversation back and forth between MCC [mission control center] and us, and then Bruce and I headed down below thinking, "This has got to be the right place to be." By about the fifth sentence MCC is saying they want to start the EVA pathway in parallel while still working out what was wrong. So we broke into that parallel path of activity.

I had remembered from 41G that the airlock depress valve cover can be hard to get off; it had slowed us up a bunch there. Charlie and I had talked about that and penciled into his EVA timeline to try to remember to loosen it the night before or early in the morning. In the blur of events, it didn't get done, so we lost time on it again. I don't know how long Charlie wrestled

with that, but it was a big holdup point, getting that puppy to move and start going. I've always wondered if we had remembered to get that done, and we had just gotten right outside before they came up with the workaround ground command, we might have gotten outside and actually seen the telescope be deployed. Instead we ended up staring at the inside of the airlock wall while the telescope was released. Dimly thinking, "I only worked for five years on this thing, and I'm not even getting to watch it being deployed!"

In fact Steve was queuing up some video the next day, some stuff he had taped onboard to play down to the ground for recording. I came up from the middeck just as he got it set on the monitor, and the sight froze me in my tracks. So the only glimpse I ever had of the telescope flying free was looking over his shoulder seeing it on the monitor. "Oh, that's what I missed! Darn!!!"

ROSS-NAZZAL: I'm sure you and Bruce had an interesting conversation in the airlock.

SULLIVAN: Well, there's really no way for us to talk. Our suits are tied into the ICOM [Intercom] loop, so there's no private way to chit-chat just between us in the airlock. What Charlie, Steve, and Loren need to be doing is talking together and coordinating closely on what they're doing, and air-to-ground needs to be quiet except when it's needed. So other than a couple of sentences exchanged that boiled down to, "We're going to proceed with the deploy timeline here. You guys stay put; we're not going to come get you out," and a confirmation back from us that that's the right call, we didn't say a thing; we just listened.

And that was absolutely fine, because I wanted to hear what was happening, and hear that it was going right. I know neither of us wanted to be just gabbing on the loop and cluttering up

the airwaves with conversation that wasn't directly relevant to getting the telescope deployed. I just stared at the nice smooth white inside of the airlock and listened to intercom and air-to-ground until it was deployed. Now, once they had done the release and you felt the thrusters fire, you knew we were backing away, then it was, "Okay guys, how long are you going to take before you remember to come down and get us? Come get us while we can still see the telescope. If you get us out of here fast enough, we get to see it too!"

[End of interview]