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WILLIAM H. GERSTENMAIER
INTERVIEWED BY JENNIFER ROSS-NAZZAL
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ROSS-NAZZAL: Today is June 7th, 2017. This interview with Bill Gerstenmaier is being conducted at NASA Headquarters for the Headquarters Oral History Project. The interviewer is Jennifer Ross-Nazzal, assisted by Rebecca Wright. Thanks again for taking time today, we certainly appreciate it. We know your schedule is quite busy.

GERSTENMAIER: Thanks.

ROSS-NAZZAL: We wanted to start with your time at the [NASA] Lewis Research Center, now the [NASA] Glenn Research Center [Cleveland, Ohio]. You started working there after graduation from Purdue University [West Lafayette, Indiana], and you went to work in the Wind Tunnel and Flight Division. Had you been a co-op [cooperative education student] or an intern at that point? How'd you find out about that opportunity?

GERSTENMAIER: No, what happened was at the university the various recruiters came in, and then you got a chance to go interview with folks that came in. Somebody came from the Lewis Research Center at that time, and I did an interview with them. I was kind of interested in propulsion and aeronautics. My background was more on the propulsion side from school for my B.S. [Bachelor of Science] and with interest in aeronautics, so I'd interviewed with a lot of different companies. A NASA recruiter came through and said—kind of typical to even where we are today—there weren't many openings. They weren't hiring very many folks, but they would go ahead and give it some consideration to see if I could go to work there.

It was an interesting recruiting process overall. I had interviewed with a lot of different companies, with McDonnell Douglas [Corp.], with General Dynamics [Corp.] in San Diego [California], with General Electric [Co.] in Cincinnati [Ohio]—all in the aeronautics world—and Pratt & Whitney also. What was intriguing to me was that almost all those companies had some relationship back to NASA.

So then the question for me was, "What did I want to do?" Did I want to go work in one particular area of aeronautics and be pretty stovepiped? Or did I want to go to NASA and then actually get a much broader exposure to a much larger industry? I thought "Boy, it'd be kind of neat if I got a chance to go to NASA and do that broader industry."

It was interesting. Of all my salaries that I was offered, NASA was the absolute lowest. I still remember my starting salary was $13,056, which is absolutely amazing. It was the lowest of any offer I had from any company. I didn't realize—at the time that wasn't a big consideration—but I just thought the value of the work, and the chance of being in the oversight role would be really good.

It turned out for me I think to be, first of all, really good to go into wind tunnel and flight and test. I think it's really good to do some hands-on experience early in your career. I got that same advice from many of the companies I interviewed with. I did not do a co-op term with anyone, but I got that advice to go do something that was practical, more hands-on. Because later you can do the analytical, you can do the programmatic, you can do the operations stuff. If you have a good solid test background, it's really something unique to get early in your career. So that was another advantage of going to Lewis at the time.

Again, I think that's how I came about selecting Lewis. I was lucky they had an opening. It was a tough time at Lewis because they were still in the reduction-in-force timeframe after Apollo. They had gone through significant personnel reductions over that timeframe. I don't think they had hired anyone in about five years, so I think myself and another employee were the first two employees to come to Lewis in about five years. There was not a whole new group of interns or students or employees coming in. There was like two of us, so it was pretty small.

It was a great environment to go into. All the people I worked with were really senior researchers. Most of them had written my textbooks or had contributed to textbooks that I had done in aeronautics. So I was getting a chance to work firsthand with all these folks that really, really understood aeronautics. They were tremendously nurturing and really helping me to grow in my career.

There was a program kind of like we have today where you get assigned a mentor. I was assigned a mentor, and his name was Joe [Joseph F.] Wasserbauer. He was just a great person. He was doing supersonic research and wind tunnel work. Just an unbelievably great expert, and he would just spend the time. There wasn't a question that I couldn't ask him that he wouldn't find time to go answer.

They put me in the wind tunnel very early, doing wind tunnel tests. I did some early Space Shuttle stuff, some other activities with them. I did some supersonic inlet work with them, doing some analytical papers, but my job was predominantly to do test data. Then the test data would be compared with the analytical results or computational fluid dynamics [CFD]. The idea was to then improve the overall computer fluid dynamics models and to build how-to procedures for how you used the new models based on wind tunnel data. What step size you pack in place, how you set the mesh size for analysis, other pieces. It was a tremendously great learning environment.

I ended up working third shift a lot, in the middle of the night doing wind tunnel stuff, but it was great. I was actually in charge of running the wind tunnel probably within the first year, and this is the 10-by-10-[foot] supersonic wind tunnel. There was a one-sixtieth-scale Shuttle model that went into the 10-by-10 supersonic wind tunnel. It had the orbiter and the external tank and the solid rocket boosters. We tested all those various configurations, provided the data to Rockwell [International], then they used those to essentially verify the Shuttle ascent models and the Shuttle data models.

We also participated in air data probe calibration. Those are these little probes that pop out at Mach 3. We actually calibrated those little tiny probes, so we had a very large-scale nose of the Shuttle with two little probes that pop out the side. We provided the calibration data that then went into the Shuttle algorithms to have the Shuttle land on the runway.

What was interesting was those tests were done at Lewis in the 10-by-10 tunnel, they were done at [NASA] Langley [Research Center, Hampton, Virginia], and they were done at [NASA] Ames [Research Center, Moffett Field, California]. The results from the three tunnels were slightly different. They didn't yield the same calibration curve to determine your airspeed and angle of attack and yaw. So the big debate was which tunnel was right?

We got in a great debate between the three Centers about whose tunnel was right. So then I spent a significant amount of time actually calibrating the 10-by-10 wind tunnel itself. We put a big probe in there, like you'd see on the front of an aircraft or a supersonic airplane with a supersonic probe, and then we surveyed the entire dimension inside the tunnel to show that our data was more accurate than any other Center.

We had to get accuracy within like a half a psf [pounds per square foot], which is a fairly tight accuracy. We uniquely calibrated each individual pressure transducer, made sure that it was right. We did everything possible to make this super accurate, because otherwise when the Shuttle came down you wouldn't make the runway. You'd either be long, short, or it just wouldn't fly right.

We debated and debated and debated—and I was a brand-new employee, I didn't have any idea what was going on. I would go to all these meetings and there'd be these huge debates about whose wind tunnel was right, what curve was going to go into the Shuttle. Finally, in the end, we could never really decide. So we took the results from all three tunnels, and we root sum squared them together. It's a mathematical way of averaging the results to actually build the calibration curves that went into the Shuttle.

The cool thing was then later I go down to [NASA] JSC [Johnson Space Center, Houston, Texas], and I hear how these air data probes work and how they operate and how accurate they are. The folks that are telling me this have no idea that I actually know how all this was built and how it all came about. The myth was radically different than the actual reality of the way we put these together. It was serendipity that I went down to JSC and got to see that other side. It was neat to see how the data that we took out of the wind tunnel then got used by a whole variety of folks, because I didn't know exactly where the data went. I would take the data and then provide the data to Rockwell or whoever, and it went off into the system.

That's how my career started at Lewis.

ROSS-NAZZAL: That's an interesting opening. Would you tell us about wind tunnel tests? Can you walk us through? What did you anticipate it was going to be like when you first started there? What did the old-timers tell you about using a wind tunnel and how to operate it?

GERSTENMAIER: The wind tunnel is really unique. The 10-by-10 tunnel is a phenomenal tunnel in the fact that it can be run open-cycle. What that means is you can actually have a full-scale jet engine in there. There were some [Lockheed] SR-71 ["Blackbird" aircraft] engines in there, supersonic engines. They were actually running, and they would run all the way up to Mach 3, Mach 3.5, all the way down to Mach 1. This is the largest supersonic section of wind tunnel around.

We did a lot of work. The folks I worked with actually built the tunnel, so they would show me how they did the tunnel design. You have a nozzle up front that accelerates the air coming through, essentially huge compressors. You pump the tunnel down to a lower pressure, about two psi [pounds per square inch] or three psi, and then you use these huge compressors to just flow the air around. They go through a nozzle. Then there's a secondary throat after the test section where you can reclaim some of the energy and expand it back out.

All that was done basically with slide rules, and there was a book called the Ames Tables which show the shock angles that sit at various flow conditions off of objects and pieces. Those tables and that manual lookup stuff was used to design these facilities. The throat that moves is actually large stainless steel plates. They're maybe about two inches thick, and they're driven by hydraulic rams that actually change the throat section, and that gives you the variable speed going into the test section.

For me it was a great chance to see all the aeronautics that I had learned academically in school. And now see how it actually gets applied in the real world, and how you actually use the equations and how you use these tables. How do you actually get the flow to go do what it's supposed to go do, and what is total temperature, what is total pressure, what is Reynolds number. All these things, I got a physical feel for what those were, and they were no longer just academic abstract ideas. They were physical things I could go see in the tunnel. I could go demonstrate, I could make changes in the physical hardware, and then see how it affects the flow and other aspects. The practical nature was just huge to build off of the academic world I had done. So again, it was just a tremendous learning experience academically.

Like I described, I also got stuck in to go run the tunnel, because nobody wanted to work at night. So that even helped me later in management experience, because now I'm in charge of these technicians that are running the tunnel. Here I am, fresh out of school, brand-new. These guys are very experienced technicians, really, really good at what they do. Most of them would work other jobs, and then they would come in and work at night. The technicians we had, they were all civil servants at the time. The tunnel was totally operated by a civil servant workforce. That was unique in the fact that later they became a contractor, and then there was a more formal relationship between NASA and them. But when I was there they were all civil servants. You would just work with them. "How do I motivate them to work extra hard and to help me get the right wind tunnel conditions?"

We had to run at night because we competed with electricity for Cleveland. The cost of running the tunnel was about I think $1 per second of on-time condition. That's like $3,600 or whatever it is per second of run time. It was very expensive, so we would call the electric company and we would negotiate with them when we could go run. There was a lake in New

York that they would pump up at night with water, and then they'd let the water run through during the day to run turbines to provide power to the grid. We would compete with this lake in New York. When they were not pumping the water up in the lake for the next day, then we would be able to go run the tunnel.

So that was a big, interesting dimension of now I'm negotiating with the power company when we're going to run. Here I am really inexperienced, thrown in this whole world, and they just delegated to me the responsibility to manage a small team of contractors, to negotiate with the power companies, to set everything in place. Just an unbelievably great experience to learn that stuff.

You see later in your career how all that plays out, but it was just phenomenal. I don't think I can ever thank the folks I worked with there enough. They really gave me a strong basis in engineering. They gave me a strong basis in management. They really, really helped me from a career standpoint. I'm indebted to them today. I can't think of a greater place to go.

Also, like I described before, it was unique in the fact that they hadn't had anybody new for a while. Here I was as a freshly new employee, basically the age of most of their kids, so they really almost accepted me just as a kid or a parent. It was an unbelievably positive nurturing experience. It was really, really, really, really good. That's how I guess I would describe the tunnel activities and pieces.

ROSS-NAZZAL: How many people were on the team? You mentioned you were overseeing a team of folks.

GERSTENMAIER: I would say it was probably about five people during a typical wind tunnel test at night. We would typically come in like at 10:00 or 11:00 at night. We'd get on station, pump the tunnel down, negotiate with the electric company, and then begin the actual runs at night. That's the way it went.

There's a couple pictures of me in the tunnel when I was there. That was also intriguing for me, because I was very much focused on wanting to do wind tunnel tests. I remember we delayed one test because we wanted to have a picture of us in the tunnel to try to get on the cover of *Aviation Week* [*& Space Technology* magazine]. I'm just like, "No, no, no, we need to go run. We don't need to get this picture. We need to go get data because this needs to go to Rockwell to go satisfy some analysis they're trying to go do." But then I learned the importance of sometimes you have to show the broader community the importance of what you're doing. It's not all just about getting the data. It's also leaving a physical record of what you've done, and let other folks see what's occurred. That was, again, just a tremendously great experience.

We had huge challenges in the tunnel. One night we left one of the hatches open, and it sucked in a bunch of debris, gravel and dirt from the outside. Then that pelted the front end of the Shuttle model and caused some minor damage to the Shuttle model. The worst thing was it put dirt into the tunnel. We spent multiple days trying to clean the dirt out of the tunnel, because it would be in other locations and other pieces.

That was one thing where I learned the importance of being very focused on all the details. It's not just getting the tunnel up. "Are all the hatches really closed? Have we really done all the walk downs? Have we done all the preparation before we actually go do the start of the tunnel activity?" That gave me another chance to see that dimension.

One night we were running, again, the sixtieth scale model of the Shuttle stack, and we had solid rocket boosters on the side. The instrumentation was actually inside the solid rocket boosters. So when you're running at like Mach 3, the very front end of the model is extremely hot, is really warm. As the shock wave forms, the temperature drops to very, very cold at the back.

We had these pressure transducers we were using to measure the pressure inside the model, inside these mock-ups of the solid rocket boosters. They were water-cooled. We had a water-cooled system in there to keep them—because the front of the model would get hot, we needed to keep those pressure transducers at a stable temperature. So there was water loops that kept them at those temperatures.

One night we were running, [and] something happened. First of all, we saw a fuse blow in one of the controllers for these pressure transducers. They were called Scanivalves. They had one pressure transducer in the middle, and then they had like 72 ports around the side. The little device would rotate around, sample each pressure port, expose that to the pressure transducer, and then it would get recorded in the data system. We were running at night and a fuse blew that was driving those little Scanivalves to do the rotation of the pressure thing. I didn't know what it was. Then we changed the fuse out, we put another fuse in, we ran for another minute or two, and the fuse blew again. We thought "Hmm, wonder what that is." I didn't know what to do. We put a third fuse in, the third fuse blew. We finally ran out of fuses.

Then I had somebody [say], "Well, we can go look in the window." We looked in the window, and out of the back end of the solid rocket booster was this large icicle, probably about three or four feet long. What had happened was one of the water lines broke inside the solid rocket booster, which provided cooling, and it shorted out the electrical system. That's why the fuses were blowing. We didn't know that. The back part of the model, because it's behind the shock wave, is like at -300 degrees. So that water essentially froze as a solid piece just straight out. There was this solid icicle right out the back of the solid rocket booster about three or four feet long.

It was pretty amazing when we saw that, because it showed you the physics of what's going on. Here the front of the model is 100 degrees. After all these shocks it's -300 degrees such that that water just leaks out and instantly freezes. It gave you that physical thing. It was humorous, because then we essentially broke off the icicle, we put it in the freezer, and we tagged it. We kept it. As I described to you before, the run time was like $1 a second. We determined this must be the most expensive ice ever made in the history of the world. We had some Christmas party, so I think we broke up the icicle and used it as part of the ice for the activity we had at Christmastime.

What I learned out of all that was first the physics of the engineering side, but then also the fact that when a failure occurs, you need to now think about, "Why did the fuse blow?" We should have looked out the window at the very beginning and not continued to keep running and just change out fuses. So again, that was another piece of learning that was important later in my career.

I can't stress how much fun and really great opportunity it was to just learn how to become an engineer. That's essentially what I learned at Lewis during that timeframe, was really how to become an engineer.

ROSS-NAZZAL: How did you capture that data? Were you taking photos, film, magnetic tape?

GERSTENMAIER: We had a computer system. The pressure transducers were calibrated with signal conditioners. I think the high-speed data was captured as analog data, and then the slower data was captured as digital data. There's large data books available, and they were on big disks that were kept on essentially mainframe computers off in another building someplace that would actually do that. We were at the transition between digital data systems and analog systems. So a lot of the systems in place were analog, where they just recorded the actual value of the current coming through a device, whereas some stuff was starting to get done digitally.

The other advantage to me was I came out of school, so I was very familiar with computers and digital stuff, whereas many of the folks I worked with were not experienced with the digital world. I would do a lot of stuff on the computer. I would do a lot of stuff digitally that they were not used to doing. They would typically do analog.

Even model control, where the model sits in the wind tunnel—that was driven by an analog system instead of being driven by a digital system as it would be today. I got a chance to experience that transition from the analog world to the digital world. That was another piece of my career that was really important.

When I wasn't in the 10-by-10 then I did some subsonic mixer nozzle work, which was looking at the back end of a [Pratt & Whitney] JT8D engine. The fan stream is the stream that goes around the turbojet engine. The core stream is the hot center stream. If you put a nozzle at the back and you mix that fan stream and the core stream together, then you exhaust through a common nozzle, you can gain an efficiency in propulsion. You see it on modern aircraft today where they do this mixer nozzle thing.

I was in charge of an activity where we were looking at the shape of that nozzle that does that mixing between the core stream and the fan stream. My job was to go look at design parameters along with computer code that could help a designer figure out the way to design that nozzle to be the optimum for a particular engine. We had a facility over in Central Engineering 22 where we used to run the model at night. I was responsible for doing the model design, doing the program design. Again, tremendous firsthand experience.

What was intriguing also at that time was at Lewis there wasn't like today—as a designer or an engineer you do some of the work, then you typically have somebody check your work, and they'll sign off on the drawing as well as you. In that timeframe, as an engineer I signed off for the engineering that was being done, I signed off for the safety, I signed off for the stress, I signed off for the thermal. I did all that. There wasn't an independent group to go look at that. When we put a probe in the wind tunnel, or I put a probe in this other behind-the-mixer nozzle—whether that probe was designed strong enough to not break off and get sucked down the wind tunnel, that was up to me to make sure that probe was designed that it would work properly and it wouldn't fail.

As a new engineer I was really scared, because I knew how to do some things—I could run finite element analysis, I could do some structural work, I could do some thermal work—but I just didn't feel I had the experience to really know everything that was required. So I would do a design to a certain point, then I would go find the smartest people I could find that I knew on the Center, and I would go talk to them one-on-one. I would go, "Is this okay?" I would make them check my work to make sure that what I was doing was really right.

It was also really good because I got to see the breadth of engineering, from designing on a computer or designing on a board, all the way to fabrication and manufacture. In today's world I don't think you get that. You'll get to see one piece of the process, but you very rarely would get to see the entire process.

For example, on the mixer nozzle stuff, I would actually do designs of those. I would actually draw up the design. Then I would actually work with the draftsmen to do the drawings and manufacture. Then we'd work on the contract, go get it contracted, and built. Then we'd come back and go test it. Again, I got to see all the way from design, through fabrication, through test, and actual results back.

The beauty of all this was I got an unbelievable experience of seeing engineering and how it really works firsthand. Again, the draftsmen were all civil servants. There wasn't a contractual relationship. I could draw something up in the morning—if I wanted a new probe or a new device, I could take it over to the draftsmen. They would verify that it was right. I could take it over to the machine shop, have it manufactured. I could be in the wind tunnel with a new design the next day. It was a totally different world than where we are today with much more compartmentalized, much more segmented work, with a lot of contractor interfaces, lots of procurement interfaces. Just a tremendous learning experience, getting a chance to go work with those folks.

I will tell you again, the instrumentation people were the number one in the world at Lewis. We designed these little devices to sit in the back of the mixer nozzle to measure the velocity. Typically you would want to do that with a laser device, but they manufactured these little tiny probes that would measure velocity, direction, and angle of attack of the flow coming out of the mixer nozzle. We built a rotating shroud that would then rotate the probe behind the back of the nozzle, so we could survey that entire profile of the back of the nozzle. They did all the design of all those probes, then I got to calibrate the probes. So I went to a freejet facility, calibrated the probes, built the data, then actually built the algorithms to take the raw data from the test setup, and then actually generate the plots and data of velocity. A chance to work with really skilled craftsmen, really skilled folks, and then use their tools in very creative ways, and get a chance to do all that as an end-to-end piece. A tremendous time.

Then when I was doing the nozzle work, I got to work with the technicians quite a bit where we did the model installation. I worked with them hand-in-hand in the facility. Larry Jones was the head technician there. Again, just a tremendous mentor to me. He was unbelievably skilled at manufacturing and building, and building up the models and laying in the pressure lines.

Very methodical, and really, really a skilled technician. I was a little more impatient. I would just want to go put the stuff in and go get data, but he would take his time and put it in. I really learned from him the importance of being methodical and patient and analyzing and moving forward in doing things. He had the ability—if we needed a part, he could weld a part for us. We could put another part in. Another tremendous experience to work hand-in-hand now with the technician side, not just the engineer side.

I'll say that the three years I was at Lewis, from 1977 through 1980, were probably fundamental for everything that I've done throughout my NASA career. That experience really gave me an in-depth, firsthand experience to bridge between the academic world and what I would need later in my career throughout NASA. I stress the importance of getting a position where you're doing the hands-on kind of stuff; you're doing test and evaluation. That will really benefit you in ways you can't imagine later in your career, even if that isn't where you go later in your career.

ROSS-NAZZAL: It sounds like such a unique opportunity, as you pointed out. Do you think that was because it was such a small Center that you had those opportunities? At JSC it seems like things are pretty segmented, even back during the Apollo Program.

GERSTENMAIER: I think so. I think because it was a Research Center and it was focused on research and it was a smaller Center, it gave me a unique opportunity that I might not have gotten other places. It would not have been very good, I don't think, if I would have went directly to JSC. What I carried to JSC was I could look at a drawing or I could look at a schematic or operational procedure, and I had a physical understanding of how it actually worked. I actually knew how hardware was built, I knew what a data system was and how it actually operated and what the weaknesses and strengths were. I knew how data was collected. Those dimensions—although they're not absolutely necessary when you're in an operational environment, I think they really add another dimension that allows you to understand and operate with the parameters you've got in a very, very different way.

I think you're right that it was unique in the fact that it was a time when there wasn't a lot of new employees there. They were really interested in helping me learn. That nurturing environment of spending the time and answering my questions, and then essentially giving me really challenging assignments. I didn't feel I was really ready to go do those assignments, but they didn't have much choice. I would get assigned things that I think were probably more demanding than I was really prepared to go do. It was a great place.

I think also JSC—where there's more human life at stake, or the consequences of a failure have higher consequence, the ability to take that risk or be exposed to let somebody go do something new is lessened. There's more of a formal training, more of a formal mentoring process than there was at the research facility.

I can't thank enough the folks I worked with there. I can still remember all their faces. I know who they all are. They still were absolutely fundamental in my career. I can't think of a better place to start than get a chance to work with those folks.

ROSS-NAZZAL: Did you ever get a chance to reach out and brief, say, Rockwell engineers or some of the folks in the aircraft industry on the research that you were doing?

GERSTENMAIER: No, I didn't interface very much with the outside world. The Rockwell engineers would come in to help us take the data. They would watch us take the data, but we were a service organization where we provided them data.

It was also really important at Lewis that you advance your academic skills and potential, so they had a program where they would bring professors from the University of Toledo [Ohio] down to Lewis so you could work on your advanced degree while you were continuing to work at the Center. I participated in that program, working on a Master's degree in mechanical engineering, and I started that in Cleveland. Ultimately they wanted you to have a PhD [Doctor of Philosophy], because if you were going to be a researcher, you needed to advance to get a PhD. That was really on your career path. It wasn't sufficient to just have a bachelor's degree. You needed to advance to a Master's, eventually to get a PhD, if you really wanted to be a world-class researcher. Publishing papers was really important, but interacting with industry was not all that strong.

In the mixer nozzle world, I'd been told that we needed to be more cooperative with industry. This was just after the oil crisis in the '70s. We were looking for energy-efficient engines. That's why we were doing the mixer nozzle program. We were looking in my group at turbofans. Unducted turbofans were being looked at, high-speed turbofans. They were really looking for state-of-the-art energy efficiency.

Pratt & Whitney was under contract to do some mixer nozzle work. They were going to do some laser measurements in the back end of the nozzle—where I described to you we did the little tiny probes and put the physical probes in. Pratt & Whitney had a nozzle model that they wanted to run, get data before they actually put their laser system in. I'd been told by my bosses that we needed to be more responsive to industry. We needed to do what they wanted to go do. We needed to get them data faster than we'd done before.

I listened to all that, then Pratt & Whitney came to us and they said, "We'd really like you to go put this model in this central engineering facility. Put our model in, get some data with the physical probes if you could do that. Then that would help us be smarter when we go put the lasers in to go get the laser data and the other information." I said, "Sure, we can do that." They agreed to ship us the model, and then we had to modify the model to put in the wind tunnel.

It turned out that all my bosses were on vacation during the summer. I said, "Well heck, I can do this." Then they brought the model in. I worked with a draftsman, Oral Mehmed. He helped us build an interface between the test stand and their new model. We drew that up and had it manufactured in house, worked with a technician. We put it in place. From the start of when they shipped us the model until we actually got them data it was probably two months. Most of that time was when my bosses were all gone. They had left; there was one model in the facility. They come back, there's a Pratt & Whitney model in there, this whole new data system is in place, this whole new thing is in place. They're going like, "Well, what are you doing?"

I said, "Well, you told me to be more responsive to industry."

So we turned around this stuff, and we did all this within like two weeks. Had this whole system in place, and we got all this data for Pratt & Whitney I think within two months. We got a letter back from the president of Pratt & Whitney, said he couldn't believe that NASA could turn around a project that quickly. Again, it was just because I didn't know what was possible, what wasn't possible.

I knew who to work with. I knew who to work for, who was critical to get stuff done. We'd get stuff drawn up. I'd go over to the machine shop. I would talk to the machinists. I got to know them really well. Then after we'd get the data I would go back to the machinists and I would show them the data that we took with the devices that they built and they designed. That also turned out to be a really great learning.

Just by showing them how their work then paid off, and how their work got built into these plots, and how their data was used, I then got buy-in from these machinists. The next time around when it was time to get priority in the machine shop, they knew that my stuff was important, and I would spend time to explain to them afterwards what data we got. They would give me priority over others, even though there was maybe a more formal system. They would still machine stuff for what I needed to get done ahead of others. I learned a way to work with the community to build the spirit of, "Hey, we can really do this stuff." It was just amazing what this team at Lewis would do to turn things around. That was one example of where we just did an amazing amount of work in no amount of time.

Pratt & Whitney also wanted to look at—one thing we would do on the nozzles is they would either end like a straight edge or you could scallop them. You could cut a corner out, cut a piece out, and then that changed the flow coming out and it appeared to increase the efficiency. But nobody knew why because we weren't sure how it changed the flow. Pratt & Whitney said, "Could you modify one of our nozzles?"

I looked at the way we could do that using an electrodischarge machine to actually machine out the little scallop shape. Then we had to build essentially a carbon tool. Electrodischarge machining actually erodes the metal by creating a little arc and burns away the metal in the shape. This little device erodes after a time. You have to change the tool out. So then I built an algorithm to actually machine these carbon tools. We did it on a CAD/CAM [Computer-Aided Design/Computer-Aided Manufacturing] machine. I built the actual algorithm, I gave it to the machinists, they built the tools so we could manufacture them based off of my analog device. We then took the Pratt & Whitney nozzle and electrodischarge-machined these cuts called scallops all around their nozzle form. We put it in the tunnel and ran it, and we did that in about probably a week.

They were totally blown away that we went from a concept to actual data back in their hands in probably seven days. It was just the fact that I had the skill that I could write the algorithm to build the [computer data that drove the cutting machine] algorithm to give to the technician. He wasn't familiar with the math and the engineering to actually build the algorithm to program the machine. I could program the machine for him, but then I didn't know how to operate the machine. We would figure out a way to work together. We practiced, and then we built this whole process. Again it was just a tremendous hands-on experience, without a lot of structure. There wasn't the formality of, "You need to get approval to go do this. You need to get sign-off by a person to go do that."

You were responsible, you were accountable. If we messed up, we messed up in a big way. This was their only model. If we didn't machine it correctly we were in big trouble. So we practiced a bunch of times and made sure everything was right. We were confident enough that we could do this. Again, it was taking all the skills from the team and figuring out a way to put them all together to go accomplish this stuff.

What a great learning experience that would just pay huge dividends later in my career. Because building high-performance teams is obviously really important, how you get folks to work together—all that is really good. To actually get a chance to experience that firsthand was just absolutely amazing.

ROSS-NAZZAL: You mentioned the importance and value of research at Lewis. Did you have a chance to publish any papers?

GERSTENMAIER: Yes, published a couple papers from there with some people. They're out there, on mixer nozzles. I still have the data book in my office of the data from Rockwell. I didn't publish anything associated with that, but I have all the raw data and I have my original little test procedures and test plans that are there. It's humorous because they're typed on typewriters and ancient equipment. It's an interesting world. But yes, I got to publish a couple papers and did those things. It was really just an amazing time to get a chance to work with these folks.

I will tell you I was not as good as the researchers that were there. I really looked up to them. I could do the work; I could do some of the physical things. But the real analytical detailed understanding, they were really, really smart in those areas. They would answer my questions, but I wasn't capable of really performing at that high-level research. So I was more the data taker, more the test taker. I would do the test piece of it, then it would be compared against the computational fluid dynamics folks.

We published a couple papers where we'd do blind research, where they would go analyze say a duct or an inlet or a nozzle without any knowledge of what the wind tunnel data was. Then I would go take the wind tunnel data. Then we would publish a comparison paper where we'd compare what they did with their computational fluid dynamics, what we actually got from the wind tunnel, and they would be pretty radically different. They would go back and then they would go change their model. They would tweak parameters in their model, and then they could get very good agreement with what the wind tunnel results were.

What we were doing is we were building procedures and processes to teach the computational fluid dynamics folks how to set their models up for certain geometry and certain shapes of nozzles and inlets. We were providing basic information on how you would use this generic sophisticated computational fluid dynamics tool to be used in the real world to give you practical results coming out the other side.

ROSS-NAZZAL: What was your understanding of CFD software at the time?

GERSTENMAIER: It was pretty much just starting to emerge. So at that time I would say the true standard or basis was really the wind tunnel test. This was where it was emerging.

Computational was getting good enough that you could model a lot of things, but there were still a lot of disconnect between the two. This was the emergence of computational fluid dynamics. It was neat to be on the test side because my data was always assumed to be right, and their data was always assumed to be in error. Then I'd get to watch them fix and change things back and forth.

There's a couple comparative papers that are published along those lines where the results are there. My role was just more or less doing the physical work, doing more the hands-on stuff, and getting the actual data for them to compare with their analog results.

ROSS-NAZZAL: The tests that you did on the Space Shuttle, did you see any changes as a result to the vehicle itself that you're aware of?

GERSTENMAIER: No. Again, there I was predominantly just the data taker. I would take the data, it would go to Rockwell, and then they would use the data to confirm models or make changes.

The only time that it came about was after the [Space Shuttle] *Columbia* [STS-107] tragedy. When we returned to flight, a large protuberance air load ramp blew off the Shuttle, a big large piece of foam. That little ramp was to shield some cable trays on the outside of the external tank from flow. It was just a foam ramp they put in on the outside. That broke off.

Then we looked at removing that ramp. I knew from my wind tunnel data that all the models I ran in the wind tunnel did not have that ramp on it. So I knew there was a series of data that was available out in the real world that had all this basic wind tunnel data without that ramp in place. So I made—I guess it was [The] Boeing [Company] and Lockheed [Martin Corp.] at the time aware that this data was out there. All they had to do was go find it.

There was a whole bunch of wind tunnel data without this little thing that we would like to remove, and it seemed at least that data could be used to correlate whether it's acceptable to remove this extra piece of foam or not. It turned out later we removed that piece of foam. It was interesting. I didn't realize that some of the data that I was taking in the dark ages in the '70s would be potentially used later in the 2000s to actually affect an external tank design.

ROSS-NAZZAL: You have a good memory, if you remember that.

GERSTENMAIER: I wasn't sure. I didn't remember [if] it was there, but I had pictures, so I could pull up pictures and go look at the records, and there was no ramp on the [tank]. I wasn't positive, but I could go back and look and confirm it was there. But I knew we ran those configurations because we were looking specifically at how the orbiter interacted with the external tank and interacted with the solid rocket boosters. That was the purpose of this little ramp, was to shield this cable tray that was on the outside [of the tank from aerodynamic forces from the other components (solid rocket boosters, and orbiter)].

ROSS-NAZZAL: Curious—did anyone ever share with you the reasons why Lewis didn't try to do more on the development side of the Space Shuttle? Was there any conversation about that while you were there?

GERSTENMAIER: No, I think at that time they looked at themselves as being a research organization. Very strong roots in the NACA [National Advisory Committee for Aeronautics] world, in the aeronautics world. They were an Aeronautics Research Center, so their expertise was in aeronautics.

It was always intriguing because, for example, the supersonic turboprop stuff, that gave a fairly decent efficiency increase in aircraft. All the fundamental research was done at NASA Lewis, all the basic research was done. Then they decided to do a flight test and went to [NASA] Dryden [Flight Research Center, Edwards, California]. Then the pictures in all the magazines and all the publicity is about Dryden flying this new unducted turboprop. It was kind of sad in a way because I knew all the real work behind that effort actually came out of the Lewis folks. At the time [they] had spent an inordinate number of hours of design and redesign and verifying code and analysis and other pieces, but then they didn't seem to get any of the glory associated with the actual flight test. That all went to someone else.

I don't think we really saw that as a problem. You knew in your heart what you contributed. You could analyze what you did and where you helped and where you didn't help, and whether you got credit or not out the other side, didn't really care. The state of the art got advanced. The new process, new products got out. I think that's maybe almost selfishness of the researcher that doesn't know exactly how their research is going to be used. It doesn't matter to them, it's just the joy of doing the research. That's a great difference between the Centers, when you go to an Ops [Operations] Center like JSC compared to a Research Center like Lewis. But I don't think there was really much consideration that it was there [of Lewis participating heavily in the Shuttle design].

The other thing that used to be humorous was I would sit in aeronautics meetings, and we would have our Aeronautics Mission Directorate presentations. They would always show the Shuttle development wedge in the budgets. They'd show this chart, and all this money was going to the Shuttle Program. When that got done [Shuttle development spending], all that money was going to come back to aeronautics, and then we [aeronautics and Lewis] were going to get a chance to go do all this wonderful research [with the "new" budget]. I think every year I would go to the briefing, and there would be this Shuttle wedge. We'd talk about the Shuttle wedge, "As soon as the Shuttle development gets done, man, all this money is coming back to research." I don't think it ever happened. I think the Shuttle wedge never went away, but we used to see all that all the time.

I think the hardest thing maybe at Lewis was—like I described to you, all these cases where I was able to do these things working with these teams was just phenomenal, but it took a lot of self-energy to get all these people motivated to go do stuff. I think sometimes they got tired. They really wanted to do more research. They really wanted to go push in other areas, but the funding just wasn't there. So then they would get turned down for projects, they'd get turned down for programs. They had gone through this huge reduction in force after Apollo when there was not much money. It was hard even in the energy-efficient engine world for them, because the aircraft companies, the propulsion companies were interested in making money and reducing cost. Energy efficiency was interesting, but the basic research behind it wasn't interesting to them. So it was hard I think for the Lewis team to stay motivated. I felt that a little bit myself.

We used to joke that the motto was "yesterday's research tomorrow." We used to say that because we couldn't really do the research we wanted to go do because the funding wasn't there, so we were far more relegated to do maybe more mundane research than we really wanted.

We just didn't have the funding to push the state-of-the-art stuff. I think that was hard for the Lewis team.

Also some of the people I worked with, they had worked on supersonic transport, the big airplane that was supposed to fly supersonically, and that got canceled. So I think that was a setback to them that that never went forward. That hurt them a little bit.

They also had done a lot of nuclear propulsion stuff. Some of the folks that I worked with had done a tremendous amount of nuclear propulsion stuff, which today is [being talked about starting again]—they did stuff that was really, really state-of-the-art. That's what they wanted to keep doing, but there wasn't a desire yet in the aeronautics world to go push that state of the art, because there wasn't seen an immediate application for those things.

So they got relegated back to do more near-term, more results-oriented things and not be doing the cutting-edge stuff. I think there was a real disappointment for that research community that they didn't get a chance to do that state of the art. That's why the statement "yesterday's research tomorrow" comes out. They were doing research that was important. We would describe it as being tomorrow's research, but it wasn't really the research that they wanted to go do.

I guess if there was a sad revelation to that, there was that aspect, that they were doing great work, they could do amazing things, but [their relevancy was unknown]. By not getting the notoriety associated with some of the things, I think they got relegated to stay in the background and do more research.

ROSS-NAZZAL: Did that contribute to your decision to move to Houston and work at JSC?

GERSTENMAIER: Kind of. I kind of got to a point in my career—I thought, "Well, maybe someday I'd be an astronaut," or at least I'd go try to get into the space side of things. I thought, "Well, if I'm going to do that, maybe I ought to think about going down to JSC."

I had applied for the Astronaut Program from Lewis, and I did not get selected. Then Steve [Stephen G.] Bales in—I guess it was Guidance, Navigation, [and Control], or maybe Systems Division—was interviewing. He asked if I wanted to come down to JSC for an interview to see if I wanted to move from Lewis down to JSC.

He described to me what he had done during Apollo and being in the [Mission] Control Center. He described being on console and making these critical calls. He's an amazing person himself. He made the call during Apollo to continue on when the computers had a problem, just a tremendous person. So he describes all these things of what they're doing and what my role would be at JSC.

I wasn't fully aware of what was going on, so then I explained to him, "Well, I've got technicians that sit in the tunnel and I can look at data, but that's not that big a deal. There's nothing special about all the stuff you're describing to me. I can do all that here at Lewis." That wasn't received so well by Steve. Then he told me well I needed to come down to JSC and see what it's really like. I think I ended up paying for myself to fly down to JSC. He took me around and showed me what was going on. Then I got a chance to see that hey, there's a lot more here than just the things that he thought would be important to me—maybe being on TV, and being in the Control Center, being part of this big team. I think maybe he thought those would be attractive to me. That wasn't so attractive to me. The chance to actually build procedures and be part of the ground-up, build flight rules and procedures, and do those things, actually construct things that would be used in the Shuttle Program was more attractive to me than the console stuff and the other things that are there.

I didn't fully understand the breadth of the job, but I thought, "It's interesting." I thought, "Well, I'll go down to JSC for a period of time and see what it's like, and if it doesn't work out I'll go back to Lewis." I thought I'd go down to JSC and work for maybe two years and then go back to Lewis or go someplace else and go do something else. That was my plan.

I would say that what contributed to it was I realized that if I stayed at Lewis I could continue to keep doing good work, but it was hard. I was missing a little bit of seeing how my work fit in the bigger scheme, and how my work really contributed to moving something forward. To be part of a more active team that was actually being asked to go do stuff, whereas I felt like most of the work at Lewis we were our own champions. We were pushing some of their own work forward, there wasn't a real demand going forward. I thought well, I'd give it a chance and go down to JSC and see what it's like.

That's when I made the decision to move from Lewis down to JSC. I did that in July of 19[80]. That was an interesting time. I moved to Houston, and I'd been in Ohio most of my life up north. I like colder weather, I like winter. Then I moved to Houston in July, and it was like over 100 [degrees Fahrenheit] that entire summer of 1980. July 1980 was when I went down there. That entire summer was like over 100 for three months, and I thought, "What have I done."

It was an amazing place, but the contrast from Lewis was really dramatic. I go from a very nurturing kind of environment where people are mentoring you, they're trying to really move your career in the right position. Then I go to JSC, and it's very much more competitive.

It's really a competition. It's survival of the fittest. It's really a different pace, a different environment, a whole different feel.

It was a shock to my system, but it was cool because there was a real sense of urgency. This was before Shuttle had flown. There was a real drive to get Shuttle flying. Operations were doing a lot of stuff. I got put in propulsion, which was really good. It was orbital maneuvering system/reaction control system [OMS/RCS]. I got put into a section there with some, again, really, really good folks. [N.] Wayne Hale [Jr.] and Ron [Ronald D.] Dittemore and those folks. It was really great to get a chance to work with them. They were really experienced in building procedures and operating systems.

What I did is I tried to find things in my background that were different than theirs. I had a lot of hardware experience, I understood how hardware was built. I understood electronics probably better than they did. I could do software a little bit better than they could. So I picked areas that they were not interested in or they didn't have the same skill sets in, and I focused where I could add to the team in other areas.

It was a pretty abrupt transition to go from—I would say there was no one really driving you to get your research paper done by this date, it was just your own motivation to get it done. To an environment where this product had to be delivered, you had to be on console with this procedure or this process or this thing had to be tested in the simulators by this time. It was a very different pace and different criticality of work level and activity moving forward. I found that environment very different than the previous environment, but also really, really exciting and a really great place to go work.

ROSS-NAZZAL: You were around people more your age at that point?

GERSTENMAIER: Yes, there was a lot more people my age, which was different. I had lost that piece. Then again, it was also amazing that I'm working with all these heroes from Apollo, people that I've read about. Gene [Eugene F.] Kranz and George [W. S.] Abbey and [Clifford E.] Charlesworth and Chuck [Charles R.] Lewis. All these flight directors, all these people that are really legends in spaceflight, and I'm getting a chance to work with all them and getting to interact with the astronauts and the Astronaut Office.

It was just a totally, I don't know, just a great, great place to be. Just really exciting, really, really good. I go from I think very nurturing, important, good world to a much more exciting dynamic world. Still the same underpinnings and the same chance to grow, but now I'm growing in a totally different dimension, to now grow in the operations side. Where I got a chance to grow in the research and engineering side, now I get a chance to potentially grow in the operations side. It was really, really good. Obviously I ended up staying there for a long time.

ROSS-NAZZAL: What sort of things were you working on with the OMS/RCS?

GERSTENMAIER: We were doing early stuff for Shuttle. We were doing console procedures and crew procedures. The senior folks were probably Ron and Wayne and those folks that did the detailed procedures development for the early Shuttle stuff. We had done all the thermal DTOs [detailed test objectives] that needed to be done on the early Shuttle flights. Those are the detailed test objectives where we put the Shuttle in different orientations to see how it would operate in different thermal environments.

We also did some entry maneuvers to go see how the vehicle would actually fly. Understanding how the systems would flow, writing malfunction procedures if there was a leak in the system or this thing didn't work correctly—writing all those procedures and processes. They were all in place to some level, but they were being redefined in a different way.

Ultimately, preparing to be on console to go monitor operations during a Shuttle flight. Again great, and a really neat time, when it was very much the formulation phase of all these things. There wasn't a process to get certified to be on console. You were essentially building all the procedures to be on console. You were training yourself, teaching yourself to get ready to go be on console and operate on console. Out of that, I also got exposed to all the JSC basic culture and philosophy of how you build flight rules, how you keep crews safe, how you operate, all those things. It was, again, just a tremendous learning experience prior to the first Shuttle flight.

ROSS-NAZZAL: What are your memories of STS-1?

GERSTENMAIER: STS-1, I was on a team in the background doing some thermal stuff. On STS-1 the orbital maneuvering pods got hit by foam that came off the tank and knocked some tiles off the orbital maneuvering pods. We didn't know what that meant. We didn't know that the thermal protection wasn't there on the OMS pods, because we didn't have data. The thermal models were not very good. The big debate was, "What was going to happen to the front part of the OMS pod?" It was a graphite epoxy structure. The question was, "Would we get burnthrough, and would the hot plasma then go into the OMS pods and ignite all the hypergolic propellants that were in there and essentially cause loss of the Shuttle?"

We spent a lot of time during the flight analyzing what the best condition was. Was it better to drain all the propellant out of those tanks as we could, so if this heating occurred would that be less catastrophic or less damaging potentially than if we kept all the propellant in and then there was all this fuel that could ignite and then burn? We spent a lot of time using fairly crude analytical models and working with Rockwell and the engineering side to determine what we thought the best configuration was. The best configuration was to leave all the propellant in, we thought, because it had some thermal mass. I just remember the intensity associated with making those decisions and then working again with a team to try to analyze to the best of our ability what the entry condition should be for STS-1.

STS-1 comes back and lands with no problem. Nobody knows about any of that work. We called it a fourth team. What this fourth team did, they went off on the side and did all this analysis, all this work, just to see what we could do to put us in the best configuration for reentry. That's what I remember about STS-1.

I also remember not knowing what we didn't know. I wasn't overly worried about all this stuff like I would now [know] in hindsight, looking back [it is scary] what we didn't know. We didn't know exactly how OMS/RCS systems would work. We didn't know exactly how propulsion systems would work. We had test data, we had wind tunnel data, we had model data, we had [NASA] White Sands [Test Facility, Las Cruces, New Mexico] data. We had an idea, but we never really got to see the performance of the system until it actually flew. In today's world it'd be almost petrifying to think about all the stuff we didn't know, and we put crew on this [first] flight. I didn't think of that as anything different.

Again, at that point I was pretty much being led by the Apollo group. If you look at them, what they had done with the Moon, they did all these things that nobody had ever done before. For them a test flight with crew was a big deal, but wasn't as big a deal as Apollo landing crew on the Moon and doing all these things that had never been done before. They kind of accepted that, and we just moved forward with our job. That's the way it was.

I also remember leading up to STS-1 we had a lot of Shuttle delays, lots of problems. In hindsight that goes by pretty quickly, but in foresight it's just like we were ready to go fly. "When are we going to go fly?" If I try to put myself back then, there's a little bit of anxiety, because Shuttle I think was supposed to fly in the '70s. Here it was '81 before they actually flew. I'd been at JSC for one full year or more before we actually went and flew the Shuttle flight. I'd gotten to JSC at the right time. The group I was going into, they were essentially ready to go fly when I got there. They had been preparing for STS-1 for three, four years. They were really anxious. I remember that anxiousness associated with, "Let's go fly."

ROSS-NAZZAL: I think the crew said that they were like 110 percent overprepared. They'd spent so much time in that simulator. After STS-1, what were you working on? I don't have you on console in the front room until STS-4.

GERSTENMAIER: I stayed in the back room. I did OMS/RCS Engineering Officer, then I was in the back room doing orbit stuff on STS-2 and 3 and those missions. I was in the back room doing consumables, or doing the back room job reporting to the front room operator. I was very busy on all those flights, again building procedures.

I don't remember exactly the flights, but we learned that a little bit of residual propellant would stay in the thrusters and then it would boil off. The way the thrusters determined there was a leak was they would take the fact that when the propellant leaked out and it wasn't combusting, it would actually evaporate and cause cooling and drop the temperature. When the thruster normally fired, it left a little bit of residual propellant in the thruster, and then it would boil off and would chill it down.

The concern was we might get an inadvertent leak indication where it wasn't a real leak if you just pulsed at the right frequency. You'd fire the thruster, then you'd stop and you'd fire again. Then you could maybe drive that temperature down. I built a procedure to go actually fire the thrusters at a certain pulse cadence to try to drive that temperature down and generate a false leak. That was on one of the early Shuttle flights, I don't remember which one it was. It's the one where I think we had the APU [auxiliary power unit] problem, and we had to come home earlier. That might have been STS-3 maybe.

ROSS-NAZZAL: I think it was 2.

GERSTENMAIER: Maybe STS-2. It was [Richard H. "Dick"] Truly.

ROSS-NAZZAL: Yes, it was Truly and [Joe H.] Engle.

GERSTENMAIER: Engle, so it was 2. I built that procedure to go look at the cooldown phenomenon of the leak indicators on the OMS/RCS. Again, I didn't know exactly what I was doing. We had a normal thruster checkout procedure just prior to entry where we fired all the thrusters on the Shuttle to make sure they all worked correctly. I put that little procedure in to drive these things down to the leak indication in that normal procedure, because that was an efficiency way to do it.

Then we had the problem with the APU, and they did the test. I'm thinking like, "Oh, this isn't going to be really good. If these things actually all show up leaking, here's all these yaw jets they need for entry, and they're going to have all these false leaks all over the place. It's going to look really terrible." I didn't bother to tell anybody I had embedded all these procedures in the normal thruster checkout thing. I just remember thinking, "Oh, I sure hope this goes well," watching on console. It turns out they got cold, but they didn't get cold enough to give the false leak indications and everything was fine. But, again, I learned that I got to watch what I'm doing and make sure that others are aware of what I'm doing and where it fits in the other procedures.

In hindsight, later in my career I see others do that that work for me now. I have to remember to be nice to them because I did the same kind of thing where I didn't fully understand the implications of what I was doing. I just thought, "Well, this is an efficient way to get it done." I didn't realize that there were bigger considerations. That was whenever it was, STS-2 or 3. It was one of the early flights. That's the kind of stuff I did.

I did a lot of thermal analysis. We had some crossfeed lines where the propellant flowed between the OMS pods. We predicted one region to get really cold so we had to build these procedures to actually flow propellant during the flight to keep them warm. It turns out that they didn't get cold. The analysis was wrong. They actually got colder when we flowed propellant through them. [These are the type of procedures that I developed.]

I got a chance during that timeframe, even prior to STS-1, to brief John [W.] Young and Bob [Robert L.] Crippen directly in flight techniques meetings and tell them what we were doing from an OMS/RCS standpoint. In hindsight a tremendous exposure to get a chance to interact with the crew. I remember John Young was an amazing person. He would ask these questions that appeared to have no basis in anything, and then I would answer them. Only after I answered about three or four of his questions would I figure out what the heck he was really driving at, and I'd go, "Oh man, this is not good." He was really, really, really sharp. He just had the intuitive [nature and wanted to make sure that we knew what we were doing]. I don't think he was being devious or trying to trick us, but he was just making sure that we really knew what we were doing.

He would ask what would appear to be like, "That's like a really stupid question." In reality it was a really important question that was underpinning a much deeper knowledge that required you to really understand your stuff to answer in the right way. He was, in a sense, testing us to see if we knew what we were doing as we were building procedures for them. It was a tremendous experience to work with both him and Crippen at that time and get a chance to work with them on OMS/RCS stuff.

All the stuff that Steve Bales talked about with me when I came down which I didn't fully appreciate—I got to actually then see how it is really cool to get a chance to be interacting with the flight crew. And explaining to them what you're doing, and essentially teaching them your system and how your system operates, and how they're going to have to interact with the system. It was, again, just a great, great learning experience, especially in those formative years when there weren't procedures, there weren't processes.

We were all learning at the same time. I really like that environment where it's not so established. It's a chance to really learn, and there's not a process or procedure you absolutely have to follow. There's not a console procedure test you have to take, there's not an exam yet. You're teaching yourself to get prepared to go do this activity moving forward. I really like that environment. It was a great time to be there for those early Shuttle flights.

ROSS-NAZZAL: When you became a PROP [Propulsion Engineer] then there was no certification required?

GERSTENMAIER: There was still certification, but it wasn't formal the way it is today. You had to do some workbook stuff, but the workbooks were fairly rudimentary. Some of them were not exactly right. They were built predominantly to train the crew, so we were taking the procedures and processes that the crew had used to train. The actual process and the amount of courses you had to take, that came later in my career. That wasn't there at the very beginning.

At the very beginning you were still certified, you still had to sit on console. They'd give you failures, and you'd be graded by your peers and by your supervisors. You'd be determined if you were sufficient to go on console or not, but it wasn't as formally documented with the set of rigorous classes to take and procedures to take. There were some, but they weren't nearly the rigor that came later. You would do some stuff in the trainers in Building 5 to see systems. You would do some stuff with the workbooks and other things, but most of the learning was actually from building the procedures yourself, building your own console procedures in the simulators.

Also a tremendous learning experience, because you got a chance to go over to the simulators. As you're building a procedure, you're really learning how things work. You're learning also how the simulator works, how the simulator doesn't work, where it models the real world, where it doesn't model the real world. That was good.

ROSS-NAZZAL: You were on console in the main room for STS-4, which was the last OFT [orbital flight test] flight. What are your memories of that mission and the OMS/RCS system?

GERSTENMAIER: It's interesting. Maybe in hindsight people think of orbital flight test as being some demarcation of "Shuttle was then operational." I don't see it that way at all. They may have said that on the outside, but internally we were still learning. We were still experimenting with systems; we were still pushing the Shuttle. There was a lot to do.

I don't see a differentiation of much between STS-4 and the [later flights]. It was more how we started using the Shuttle. Later on, like on I think STS-7 we did some rendezvous prox [proximity] ops [operations] stuff. I got to develop a lot of the rendezvous prox ops stuff. It was interesting. I interacted with the GNC and the FDOs, the Flight Dynamics Officers. Then we were building procedures on how to use the Shuttle OMS/RCS systems to actually maneuver the Shuttle to accomplish an objective, to rendezvous with some target, to do some activity.

My role was more how you use physical hardware to accomplish these other goals, but then I got to learn rendezvous prox ops and bingo numbers and all that stuff. All those early procedures development and stable orbit rendezvous—I got to work with the Mission Planning and Analysis folks who did a lot of the work behind the scenes—almost like what I had done in Cleveland—take their research and figure out a way to actually apply it to flight. How you actually turn that into a flight procedure that a crew goes off and executes, and how do you do this in the best way that ensures mission success.

I didn't see STS-4 as anything specific. If I go back and I look at the crews, and maybe I go look at what payloads were on there and what the mission objectives are I could tell you where they are. But somehow those are all lost in my memory somewhere. I remember some crews, I remember some activities more than others, but I don't remember any real specific notable things about that. Learning to operate in the front room was different, being on console was different, interacting with the flight directors was different. The training level was fairly intense.

I liked orbit a little bit better than ascent/entry. I did orbit first. The reason I liked orbit a little bit better is it wasn't as structured. You had a chance to actually change things. The time constant before something happened that was bad was longer, so you could be more innovative, a little bit more creative. If a payload didn't deploy or something happened that was different, you had time to go work things.

Our predominant job was to make sure that the amount of propellant we had for this mission was protected so the crew could do a safe reentry and had enough propellant to come in and land. That was our job on orbit, was to make sure we preserved that propellant for later uses in the mission. We had pretty sophisticated ways we calculated that, and how we monitored burn performance on orbit to see if the thrusters were using the right amount of propellant, and we were keeping propellant balanced between the forward and the aft and prepared for contingencies to come home early if we needed to. That was the orbit role. You could be more innovative. You could be more creative.

Ascent/entry on OMS/RCS you had to be really quick. You didn't have much time when a failure occurred to when you had to make a call, so there was no chance for creativity. You needed to know exactly what was going on in terms of a leak, what was happening in the propellant system. You needed to make a split-second call. That was life or death for the crew whether that call was right or not, so that was really, really intense.

In that phase of my training on console operations, I really wanted to simulate as much as I could on console. I would want to sim at least three times a week to keep at that high proficiency level, because it had to be just second nature to you. You had to use the products, the tools. You needed to know exactly what to go do. You didn't have a chance to go, "Okay, which book is that in? Should I go look at this other book?" There was no choice.

That was a very much more intense phase. That's the big change, going from orbit to the ascent/entry phase. Entry for OMS/RCS was really, really critical too. The interactions with the Guidance, Navigation, and Control folks was really important. A very dynamic, really critical time to really monitor systems. You really needed to know your stuff.

I would say probably the most senior folks were in ascent and entry. You typically started on orbit, and then you moved to ascent/entry. I remember much more the transition from orbit to ascent/entry than I do the transition from maybe back room to front room, or even the OFT demarcation.

I don't really see STS-4 any different than STS-5 or 6 or 7. I see those really as a continuum across the Shuttle spectrum. The Shuttle could do more. We did more stuff with the Shuttle, but we were still doing DTOs. We were still doing thermal stuff; we were still checking things out.

ROSS-NAZZAL: I did notice when I looking at STS-5 and some of the other missions—when [Space Shuttle] *Discovery* came on board—there was still a lot of testing going on. I was kind of surprised to see that in the press kits. All the tests that you were doing on the systems, I thought you knew quite a bit about those systems. So you were constantly learning, every mission?

GERSTENMAIER: Yes, every mission. We would do certain thermal DTOs, and they'd be more stressful than the other ones. I remember we exposed one side of the Shuttle to high temperatures for an extended period of time towards the Sun, and it actually bowed the Shuttle enough that the cargo bay doors would not go closed. So then we had to go reorient to a different attitude to unbow the Shuttle so the doors would go closed.

We were really learning what the vehicle could do and couldn't do in various applications. Where our thrusters got too hot, where things got too warm for your systems, you really started learning how your system really performed. Then your job was to document that, write that down. Then the next set of folks or a mission came up where you wanted to do something more demanding, you knew how the vehicle actually operated and flew. I think we were in flight test all the way through the end of the Shuttle Program. In the outside world it may have got portrayed we went operational. I don't believe we ever went operational. We were always in some level of flight test.

ROSS-NAZZAL: You mentioned how dynamic ascent and entry were, that you really had to know your system. Were there ever any moments where you really had to recall that information that you remember?

GERSTENMAIER: Yes. One of the fairly early ones there was a reentry, and we lost the relay box that configures power to the valves. We had this thing called the OMS/RCS slide rule. It was a piece of paper, and you would slide it back and forth. Depending on which power bus went down, it would show which valves you'd lose telemetry from, which pressure transducers. You could use this slide rule to figure out fairly quickly which power bus had failed right off the bat.

I just remember being on console during an entry and one of the circuit breakers or these power controllers failed. Just by looking at essentially the lights on the console I knew exactly which switch it was, exactly where the power controller was, and exactly what the crew needed to do. I remember making a call to the flight director to have the crew configure the switch, and it was exactly the right switch.

It was almost second nature. I had trained so much that there wasn't really a whole lot of cognitive thought. It was just visual recognition. "These lights are on. This is the error. This is more than likely one of these devices. This is the device that it probably is. Here's the call, go."

It was remarkable to me. It was like a high performance athlete when you set the world record or you set the personal record. Sometimes when that happens you just feel like you're in the groove and things are clicking right along. That was exactly the feeling I had afterwards. It was just like yes, that's exactly where all those hundreds of hours of training went in. I got a chance to actually see the scenario and do exactly what I was trained to go do. It wasn't a big deal. It was just what you're supposed to go do. It gave me encouragement that what I was doing and how I was learning was a positive way. That's why I wanted to keep that level of proficiency up.

On [the ascent simulations] it was hard. You would get to orbit with the crew [using propellant from the] OMS/RCS, and sometimes you would have used all the propellant to get to orbit such that the crew could not come home. The crew wouldn't know that they were actually lost, you actually killed the crew because you didn't have enough propellant on board to return. We'd recycle [the simulator] back around [for another simulated ascent]. Not anybody would probably know in the Control Center [what] you just [did]—the good news is we got the crew on orbit, the bad news is they're going to die because they don't have enough propellant to get home. You would know that as an ascent/entry flight controller on the PROP side, and then you'd have to deal with that. You'd have to deal with the fact that I just killed the crew. I wouldn't necessarily vocalize that to everybody. But I knew it in my heart, and I'd go, "Crap." Then you recycle again, you get two minutes. Now you're back again doing another ascent run.

That's how serious it was and what the calls were and the data you were making. You personally had that feedback of how many times you killed the crew. You knew how good you were, how good you weren't, and you had to live with that, and then know you were really prepared.

There was a lot of self-evaluation to make sure that when you were on console—I didn't care if I was certified or not—I wanted to make sure that I was at the right proficiency level that I was comfortable with what I was about ready to go do. That I was the best person to be in that slot to go do that. And if I didn't feel I was there, I would say to somebody, "It's not time for me. Somebody else go figure out a way." Even though I may be certified, I wanted that proficiency level. That was a very intense activity, a very intense period.

But again, as you look back, all those things prepare you for later things in life. I still carry that same thing today when I sign flight readiness review statements. I sign a flight readiness review statement with the same seriousness that I [had] on console, knowing that my call will cause the crew to either live or die. My evaluation of this team that we're ready to go fly is just as serious and just as important as it was when I was back on console. That same seriousness associated with your responsibilities is present in both cases. Some people might see that as paralyzing or stressful. I don't, it's life. You do it every day in your own life. You don't get it portrayed to you as starkly as I described to you, but it's there. I don't see this as a big thing, but then that responsibility is huge. That individual accountability is really, really, really important. It needs to be there.

ROSS-NAZZAL: When you walk into the MOCR [Mission Operations Control Room] today—they're going to restore it as you know—you see the mission plaques. Did you ever have the opportunity to hang a mission plaque at the end of a mission?

GERSTENMAIER: No, I never hung a mission plaque. But yes, I see them and I think about the teams. That's the other thing that's a lot of fun about our business is the team activity, that you're really part of this bigger team. None of us can accomplish these things we're doing in human spaceflight without just a huge team.

That's another wonderful aspect I think of this job. I think you know in your heart you have to be prepared, just like I described to you, to that level of performance. I expect every team member on that team to be at that same level, and that's when you really achieve amazing things. Whoever hangs that plaque it's cool because they did their piece and they got in the spotlight, but underneath them are all these other folks that did the more mundane routine stuff that was probably just as critical as the person hanging the plaque. But it's still cool. The need for everybody to work together and play flat out, to tell folks what you know and what you don't know, to tell folks what you're uncertain of, what you're not sure of—that's just as important as appearing that you know everything, appearing you know this, you know that.

You've got to be not afraid of saying, "Hey look, today isn't my greatest day. I'm tired today. I'm not performing the way I should. You watch what I'm doing today, even more than usual. Make sure that when I'm on console and making these calls." I'll tell my back room folks, "Today isn't the day. For whatever reason it just isn't quite the level. So you double-, triple-, quadruple-check me, and make doggone sure we're doing the right thing."

Exposing that vulnerability to others I think helps make the team stronger because they know when you're not there. You build that team cohesion that you're there. Then you know that if somebody else isn't there, "Okay, I'll cover for you today. I'll help you here." That's a cool thing in human spaceflight. That's one of the many things, but that's one of the things I think is really phenomenal.

ROSS-NAZZAL: In Gemini and Apollo and even in Mercury you hear all these anecdotes, these stories from the flight controllers. They liked to play a lot of pranks on each other. Was that something that was still common during the Shuttle period?

GERSTENMAIER: Yes, I think we did that quite a bit. Yes, we did stuff. We had pneumatic tubes, which I'm sure you heard about. We would put strange objects in there, like Coke cans, and then they would clog up the whole pneumatic tube system. We passed paper around through pneumatic tubes, and we put a frog in there once. We did all kinds of little things back and forth. You'd do stuff to tweak each other.

After simulations we'd do a party or celebration afterwards. Those were a good chance to just kick back and relieve stress a little bit and talk to folks. They were also a chance to informally debrief what was going on, what happened, what didn't happen. I remember a couple events at the Gilruth Center.

I remember one in particular where they had failed a temperature transducer in one of the vernier jets. We had been playing around with the ability to change the code where we actually went into the code, and we did an [assembly language] code change to ignore that pressure transducer. It was a rewrite of the software.

We were in the simulation, and in the simulator the sim sup [simulation supervisor] gave us that failure. I thought "Oh, we'll try this thing." So we tried this procedure, and we changed the software code, did everything. It looked like it worked right. The simulator run got done. Then I decided, "Well, we ought to test it to see if it really works," so I asked the sim folks to lower the temperature down like a leak and see if it would annunciate the leak properly. They lowered the temperature down and it did not annunciate the leak properly. So the procedure didn't work.

I remember the post-event at the Gilruth Center where we're all out drinking beer and [eating] pizza and having a good time. I remember Gene Kranz and Steve Bales coming to me and just lecturing the heck out of me because I should have never taken a procedure that I wasn't confident in and uplinked it to the vehicle, even though it was a simulation, because that wasn't the time to learn. What you were supposed to do on console was exactly what you were going to do on flight, and you don't get creative at all on console when you're doing simulations. What you do in simulations is exactly what you do in flight. I must have got lectured by them the entire evening for this thing. I felt really bad, and I kind of disagreed with them because I'm kind of wired to learn stuff. But I was not going to argue with them. I was not going to win. That still was a good learning experience.

I don't think without that after-event party and that atmosphere they would have found the time to really grill me, or if they would have grilled me in the office that might have been taken a totally different way. They threatened to remove me off console and a bunch of other stuff which was interesting, but I was pretty tough. It was okay.

It was good in the fact that it really drove home the seriousness of the simulation, so I think it tempered my thinking. When I'm going to do something in a simulation, just like I described to you before, it is really life or death. The things I'm doing, I better think, "Okay, I need to treat the simulation as real. I do not need to treat the simulation as something that is just a video game or just something to participate in." That stress level that I feel during simulations, it better be the same stress level I feel in flight. That's what they were effectively trying to tell me to go do. …

I think sometimes you think of these periods of when you go do pranks or you do things off to the side as wasted time. I think there's also a chance there that they can be another learning experience, that it actually helps you reinforce learning and other processes going forward. They're just as important I think sometimes as the actual activities, and maybe we don't take enough time today to do some of those things, to just go back and play a little bit or experiment a little bit or try something off to the side in a less formal environment. I think those things were important, but again I think you needed that. You needed some way to blow off steam or do things different. As you know when the old days of chili cook-offs were a big thing, and they still are a pretty big thing.

ROSS-NAZZAL: They still are, yes.

GERSTENMAIER: They were probably another level that was even more inappropriate than they are today. They were still cool, and it was a chance for us to get together. I think the team spirit carried more from not only on-console and work, but the proximity of folks in the Houston area and the Clear Lake area would allow you to do stuff with your coworkers after hours and work. I think that's another piece of the team building that's really important. Getting a chance to work with all these folks not only at the seriousness of work but also in other things in the community.

ROSS-NAZZAL: That's something else. The flight directors from the Apollo period, they had a specific bar that they would go to after a simulation or during a splashdown party. Did you guys have a location or place that you would hang out?

GERSTENMAIER: We did a lot of things after sims and flights at the Gilruth Center, so the Gilruth Center was a place. There were a couple places where in town people would go. Bill and Marie's [Ice House] and some other places, the Outpost [Tavern]. There were places where the teams would get together periodically and they would move around. I don't think we had any one in particular. Some flight directors would order burritos from a certain place for the whole team, and we would eat burritos.

There was that sense of doing things together, and certain locations to go together. It's maybe the flight test mentality, the test pilot mentality, of going someplace to just kick back and do some things that you wouldn't normally do. Get a chance also to tweak each other a little bit and do pranks on each other. We used to do that periodically even in the building with each other.

ROSS-NAZZAL: Were you over in Building 4?

GERSTENMAIER: Yes. I remember when Dick Truly flew, they recycled a bunch of his official astronaut pictures, so they put them out in the hall in a stack to be disposed of. We took his pictures—and he was in an EVA [extravehicular activity] suit—and we took his head and his arms. We took all the clocks, and where the arms were on the clocks we put his arms from the spacesuit on, and we put his head in the middle. We changed all the clocks in Building 4 to have Dick Truly's head and arms on every clock in Building 4. I remember that as being pretty humorous when Dick came in the next day. Every meeting he went to, there he was on the wall on the clock with his arms and his head, courtesy of the pictures they were throwing away from upstairs. We did silly things like that.

ROSS-NAZZAL: I think we're coming close to the end of our time today, so unless there's anything else you'd like to talk about this might be a good stopping point.

GERSTENMAIER: I think that's good.

ROSS-NAZZAL: Thank you very much.

GERSTENMAIER: Good, thank you. Thanks for doing this.

[End of interview]