DISCOVERY AND NEW FRONTIERS ORAL HISTORY PROJECT
EDITED ORAL HISTORY TRANSCRIPT

CURT NIEBUR
INTERVIEWED BY SANDRA L. JOHNSON
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JOHNSON: Today is September 20, 2024. This interview with Dr. Curt Niebur is being conducted for the NASA Discovery and New Frontiers Oral History Project. The interviewer is Sandra Johnson, and Dr. Niebur is in Silver Spring, Maryland, and talking to me today over Microsoft Teams. Thank you again for agreeing to talk to me for the project, I really appreciate it.

I want to start by asking you if you can briefly describe your background, your education, and your interest. I was reading about where you started out in school with aerospace engineering and then switched to planetary science, so talk about that and how you first came to NASA?

NIEBUR: Sure, I'd be happy to. I think like a lot of NASA employees, I was a kid who was a huge fan of all things NASA and always dreamed of getting a job working in space and working with NASA. But I was from a very rural town in Illinois, and this was pre-Internet days, so it wasn't exactly easy to find out information. In my ignorance, what I decided to do was become an engineer, and I picked aerospace engineering because, frankly, it had the word *space* in it, so surely, this is the career path I should follow to get a job at NASA. That was the extent of my research.

I got in engineering at Georgia Tech [Georgia Institute of Technology, Atlanta], got a bachelor's degree in engineering, did a lot of hands-on work, internships, and co-op jobs, and really enjoyed it, but slowly came to realize that I was heading in a path that wasn't well aligned

with my dreams. I'd fallen into the trap of getting an education that was focused on getting a grown-up job rather than my dream job.

My course was adjusted, thanks to meeting my future wife at the time, Susan Mahan, who made it clear to me that you don't have to give up on your dreams in order to get a grown-up job. She really opened my eyes quite a bit, and what I realized was that my passion really wasn't in just engineering, that I wanted to try something new. I finished up my engineering degree and then made an incredibly sharp left-hand turn into planetary science for graduate school. I will say that I learned from my mistake in picking my undergraduate degree, not doing enough research to understand it. So I went to graduate school to get a PhD in geology of other planets, having taken an Introduction to Geology course my final year at Georgia Tech. So while my preparation and research was greater than when I started undergraduate, it still wasn't all that great. I went to graduate school, not nearly as well prepared, shall we say, as the more traditional students with more science and geology backgrounds.

But ultimately, that served me quite well, because in addition to my research work in graduate school, I also got involved with NASA missions at a very early stage. It was there that I really found a great niche for my skills and my outlook because I could straddle both. I could straddle the engineering side and the science side quite well. That was when I really learned the value of being able to speak both languages and making sure that those two disparate groups were working toward a common and accepted goal. Because it is very easy for scientists and engineers to think they're on the same page and then only come to realize years and millions of dollars later that they're not on the same page at all. So that that was my educational background.

JOHNSON: It's interesting because we talk to a lot of people, and I always like to ask about that communication between science and engineering. Especially people that worked at [NASA] Headquarters [Washington, DC] because a lot of what you do is making sure everyone communicates in some of those jobs at Headquarters, those program-level jobs. I know that your background probably aided you later on when you were in that position to make sure people understood what was going on in the mission on both sides and being an interpreter for that.

NIEBUR: Yes, at Headquarters, the problem is exacerbated because it's not just scientists and engineers that you have to straddle and help communicate. It's budget people, managers, politicians, there's a lot of stakeholder groups that you have to work with at Headquarters.

JOHNSON: Yes, I can imagine, and I was looking, actually, I have the book David Brown wrote, *The Mission [A True Story]*, and I was reading about your background. I think it's interesting that you and Susan both were so young when you started your job at NASA at Headquarters. If you want to, talk a little bit about that background that you had with the Mars Program with the rovers and how that led to you, and I imagine helped you get that job. But it is interesting because most people before they go to Headquarters, they start out at a Center or it's a different situation. Talk about that and how that came about.

NIEBUR: Oh sure. Yes, I think Susan and I were quite unique in our very brief journey to NASA Headquarters. Because, as you said, at the time we showed up in the early 2000s, there was nobody at Headquarters in science, engineering, or management below the age of 55 to 60. It was definitely an older gentleman's game shall we say.

JOHNSON: Yes.

NIEBUR: In fact, the only reason that Susan got a job there, which she got one before I did, was because she came in via the Presidential Management Internship Program, which was intentionally designed to attract young people to government work. So she came in via that program, and the attitude was that's okay because she's just an intern. But she quickly proved to them that you did not have to have 20 to 30 years of experience to do a great job at Headquarters. She's the one that kicked open the door for all the younger people to follow, including me, because she proved to them, young people can get this job done.

When another job became available, I applied for it, and you mentioned my Mars rover experience. Yes, in graduate school, I was working on Mars rovers, what eventually became Spirit and Opportunity. I remember back then, you would come and give a talk as part of the interview process, and I showed up, and the other people being considered for the job gave science talks. I showed up and said, "Hey, Spirit and Opportunity will launch soon, let me give you a preview of how we're going to manage, how we're going to drive these rovers. Here's what we've been doing in the field tests out in the desert for the past four years. This is how that's going to translate to Mars. This is how the engineers and the scientists are going to work together to drive these every single day under intense pressure, and here's the kind of science you can expect to get back." The feedback I got on that talk was essentially, "You were completely unlike any talk we've had before and came in completely out of right field." Everybody was expecting a standard science talk, 'Here's my research,' and you didn't talk about that at all, you talked about how to run a mission on Mars." Eventually what I was told was that was really what cemented the job offer right there.

JOHNSON: Yes, I would imagine since this first job was as a program scientist, right?

NIEBUR: Yes, I was actually hired to run two research and analysis programs, the Mars Data Analysis Program and the Mars Fundamental Research Program. Back then, running two of those programs was considered a full-time job, and that lasted about two months before I was given more duties, mission duties, in addition to the research and analysis. But, yes, I think everybody forgets nowadays that I'm a Martian. I was hired by the Mars Program to do Mars work, and that is not what I'm doing nowadays.

JOHNSON: You said you had more duties assigned after those first couple of months, but did you stay with Mars predominantly there those first few years?

NIEBUR: Yes, I was primarily a Mars person for the first five years, or so, and eventually, I was named the program scientist of Spirit and Opportunity, yes. I had great insight into what was going on with those missions since I had started at the bottom as a graduate student, and now, I had worked my way up to a NASA Headquarters program scientist.

JOHNSON: Okay, and you worked with Steve [Steven W.] Squyres.

NIEBUR: Oh yes. Yes, well, Ray [Raymond E.] Arvidson was my advisor at Washington University, [St. Louis,] Steve Squyres was at Cornell [University, Ithaca, New York]. Ray and Steve both put in competing proposals against one another right before I started grad school, and

they both lost to somebody else. Let's just say they were competitors, and then after they lost, they each essentially had a beer with one another and decided, hey, let's win next time, and the best way to win is for us to join forces, so they joined forces. I don't know how they decided who got to be PI [principal investigator] and who got to be deputy PI, but Steve was the PI and Ray was the deputy. Ray was a wonderful and generous thesis advisor and involved me in a lot of that work. So Ray was always fond of saying that my day job was my research, my graduate research, my night job was being a TA [teaching assistant], and my sleep job was Mars rovers.

JOHNSON: Not a lot of sleep I would imagine.

NIEBUR: No, there wasn't, but, boy, if you're going to lose sleep to something, I highly recommend losing sleep to the wild, wild west days of putting together Mars rover missions and what they would look like. That was a fantastic time.

JOHNSON: Yes, I can imagine it was. When you were there, you were working on Mars, but were you also involved with the New Frontiers Program at that point? Were you starting to move in that direction?

NIEBUR: Yes, I was made the lead scientist for New Frontiers around 2013 or so, and what that meant was, at that time, the two, two-and-a-half missions in New Frontiers were part of my portfolio. New Horizons had been neglected for a while because it had such a long cruise. It was launched in 2006 and didn't get to Pluto until 2015. But I was then brought onboard as the program scientist for New Horizons because we were running into some trouble as we got closer to the

flyby. The bosses recognized that they needed a full-time program scientist attached to the mission, so that became me. I was the program scientist for the two years leading up to the flyby and then for about three or four years following the flight.

JOHNSON: Let's go back to the way New Frontiers came about. Discovery had already started as those cost capped, lower cost missions that would fly more often, and then New Frontiers 10 years later was the midrange missions that were also supposed to be cost capped and that would fly at a different rate of flights. Since you were working with New Frontiers at that point, let's talk about the decadal surveys and that relationship between decadal surveys and the New Frontiers Program and how that relationship works for choosing those missions.[1]

NIEBUR: Sure, well let me go back first to something you mentioned about the origin of the New Frontiers.

JOHNSON: Okay.

NIEBUR: Mind you this is secondhand for me because I came onboard on to New Frontiers a decade after the program started. But I arrived at Headquarters right about the time when New Frontiers was begun, so there were a lot of conversations, side conversations I had with the division director at the time, and she was intimately involved in creating it. Essentially, it came about because

[1] The National Research Council conducts studies that provide a science community consensus on key questions posed by NASA and other U.S. government agencies. The broadest of these studies in NASA's areas of research are decadal surveys. As the name implies, NASA and its partners ask the NRC once each decade to look out 10 or more years into the future and prioritize research areas, observations, and notional missions to make those observations.

Discovery was going reasonably well, but it was recognized that there are some missions that we're interested in doing that simply are never going to be as low cost as Discovery. So let's copy and paste Discovery, give it a new name, and give it a higher cost cap so that we can apply this competitively selected, PI-led mission, which was Discovery, to something bigger and see if that works, and that's how New Frontiers came about.

The political aspect to that was that the arrangement with certain members of Congress was we will support this New Frontiers idea, but the first mission has to be New Horizons. I'm sure you could probably interview Alan Stern, the PI of New Horizons, and get far greater insight into how that came about than I can provide. But there was a very quick competition that was done that resulted in the "selection" of New Horizons. But it was always understood that New Horizons or that a Pluto mission, I should say, would be the inaugural mission of the New Frontiers Program.

Now to your question about how does the decadal survey relate to it, the decadal survey took two stances early on that they still live with. The first is that the cost cap, it should always be a bigger mission than Discovery, roughly double Discovery, which is all well and good. The second stance the decadal survey took was that unlike Discovery, which is essentially open to any planetary mission that people want to propose, for New Frontiers, proposers had to choose a mission from a list that was provided. The decadal survey recommended that list to NASA, and then the expectation was that NASA would simply copy and paste that list into the announcement of opportunity [AO] and stick with it. That's what we did for New Frontiers 2, which became Juno,[2] and that's what we did for New Frontiers 3, which became OSIRIS-REx [Origins, Spectral

[2] Since it arrived at Jupiter in 2016, NASA's Juno spacecraft has been studying the interior and origins of the planet – the first orbiter to peer so closely. It seeks answers to questions about the origin and evolution of Jupiter, our solar system, and giant planets across the cosmos.

Interpretation, Resource Identification, and Security – Regolith Explorer].[3] We differed from that approach a little bit with New Frontiers 4, which became Dragonfly.[4]

JOHNSON: How did it differ?

NIEBUR: We added another mission to the list to varying levels of support from the science community.

JOHNSON: Is this another mission that was chosen, or is it another mission as an option?

NIEBUR: It was just one of the options on the list that proposers could choose from, but it was not an option that the decadal survey had put forward.

JOHNSON: Oh, got you, and was that Dragonfly?

NIEBUR: Yes, well, the option we put on the list was what we called Ocean Worlds, and it was intended for both Titan and/or Enceladus or both, and Dragonfly proposed in that category, and Dragonfly was ultimately selected.

[3] Launched on Sept. 8, 2016, the OSIRIS-REx spacecraft traveled to a near-Earth asteroid named Bennu and collected a sample of rocks and dust from the surface. The spacecraft delivered the sample to Earth on Sept. 24, 2023, when it released a sample return capsule over Earth's atmosphere, which then parachuted to the Department of Defense's Utah Test and Training Range, where the OSIRIS-REx team was waiting to retrieve it.
[4] Dragonfly (a car-sized, nuclear-powered octocopter) will deliver the most expansive suite of science instruments ever dispatched to another celestial body. Dragonfly will cover more than 50 miles of the organics-rich Titan surface, landing, collecting, and returning results that could change our understanding of life in the universe.

JOHNSON: Okay, that's interesting. So the announcements of opportunity that come out once the decadal surveys happen. Are you involved or have you been involved in writing those or getting those together or on the committee to do that?

NIEBUR: Yes.

JOHNSON: If you don't mind, just walk us through that work, the people that work on that after the decadal survey comes out and says, "These are the things that we think NASA needs to look at," and then the AO is written from that. Talk about that process a little bit.

NIEBUR: Sure, well, one thing I want to clear up first because I get very anal retentive about this.

JOHNSON: That's okay.

NIEBUR: The announcements of opportunity and the decadal survey do not have a direct linkage. We release an announcement of opportunity when our budget allows us sufficient flexibility to pick and start a new mission. Sometimes that aligns with right after a decadal survey comes out, sometimes it doesn't. The decadal survey usually has a handful of recommendations, including that mission list that I mentioned, that we consider incorporating into the decadal. But for a variety of reasons, including legal ones, the decadal survey is just recommendations to NASA. NASA then has to decide what we're going to do with those recommendations. Sometimes we accept them, sometimes we don't.

JOHNSON: Yes, I've heard it described as an aspirational document.

NIEBUR: Well, they describe it that way because they historically assume a rosier year budget outlook for the decade than what we ever see.

JOHNSON: Okay, so it's a little more?

NIEBUR: Yes. From a pragmatic aspect, it is aspirational because two out of three times we've had a decadal survey, and the budget has been cut within months of the decadal survey being released. It's, at this point, getting to be a rather spooky coincidence.

JOHNSON: Yes, I know budgets are a whole other subject right there.

NIEBUR: Yes. But you asked about my role with announcements of opportunity. I write them. The lead program scientists for Discovery or New Frontiers, one of their primary jobs is to run the competition that we use to select the next mission. A big aspect of that is writing the AO, releasing it, running the review, and getting a mission selected. It is a very intense, very stressful job. It's also one of the rare times in government where, ultimately at the end of it all, there's one person held responsible for the outcome, good or bad, and that's the program scientist. So we actually don't have large teams working on announcements of opportunity. It's usually the program scientist and maybe one to three other people who are providing significant input, and that's it.

JOHNSON: That's a lot to take on. When did you start working on those? Since 2013, you became that program's lead program scientist, were you working on them before then?

NIEBUR: Not for New Frontiers. Around 2013, I had just finished an announcement of opportunity to select NASA instruments for ESA's [European Space Agency] Juice [Jupiter Icy Moons Explorer] Mission. I had written an announcement of opportunity for a Europa Mission that once I got that written, we just threw it in the trash because the situation changed, and then in 2014, I wrote a new one for Europa Clipper and executed that. But for New Frontiers, the first one I was involved in was in 2016, 2017, the fourth New Frontiers opportunity.[5]

JOHNSON: It's been interesting learning about Discovery and the way they do it, and of course, those missions are more often. But, like you said, it's a big job, I would imagine, for one or two or three people even to get that done. I know that those announcements of opportunity have also changed somewhat since they first started with Discovery and then when New Frontiers started. Is the process a little more streamlined as far as getting those written, or is the community more used to seeing them? How is that working out?

NIEBUR: Yes, we have been doing AOs for 25 years now. The answer to your question, is it more streamlined? It's both yes and no. The bulk of the AO now is fairly boilerplate language that doesn't change too much from opportunity to opportunity and from program to program. But the process itself—and this is the most exciting part of being involved in AOs—the process itself is

[5] Europa Clipper launched Oct. 14, 2024, on a journey to explore Europa, Jupiter's ocean world, and is the first mission designed to conduct a detailed study of that moon.

always undergoing evolution and self-assessment and improvement. So that means that an AO that was released in 1995 is dramatically different than the one released in 2003 versus 2007 versus 2015 versus the one I'm working on right now in New Frontiers 5.

The bones and the structure are very similar, but the content is much different. In very broad terms, our expectations for what we see in proposals, which we have to describe in the AO, today, are much higher than they were 20, 25 years ago. We actually have metrics showing that the AOs have gotten more and more complicated and longer and have more requirements, and we've been trying to rein that in, and that's been very difficult.

But the other fascinating thing about AOs is you do an AO, you pick a mission, you build it, things go wrong, and then you start thinking, "How can I prevent some of those problems from occurring for the next mission? How should I change the AO to help avoid reliving that problem on the next mission?" That's part of the evolution of the AO process as well. Very early on, the idea was, if we ask for more information, if we pack more into the AO and more information into the proposals, surely, we'll avoid some of the problems we're experiencing. That's why the AO started getting longer and more complicated. But now, we reached a peak on that about five years ago, and we're trying to dial it back because what we're realizing is continuing to increase the complexity and the information in AOs and proposals is not helping us further. We've reached the peak, so we've got to be very diligent and very disciplined to stop ourselves. The last AO I wrote had 103 requirements in it, that was six years ago. The AO I wrote four years prior to that had 80 in it. We've got to make sure that the next AO we write doesn't have 150 in it because those additional 48 requirements probably aren't going to help us.

JOHNSON: Okay, and the level of detail, the people answering these with the proposals since the beginning, I would imagine the science community is getting more used to proposing these missions for NASA. Talk about the level of detail since you're saying it's more and more requirements, and they're proposing to do something that they haven't built yet, that they don't yet have all the plans in place, but there's a lot of detail they have to give. And then when they start, they get chosen, they start working toward it. Does a lot change because of that?

NIEBUR: Yes. Well, that's exactly it, and there's also this idea of giving everybody a false sense of confidence. Because, as you said, it's early days, and you can work out things to the eighth decimal place and think, wow, I really understand that. But in reality, what you should be doing is rounding to the nearest 10, because you're so early on in the process. You fool yourself into thinking, I know this to five decimal places, we're in really good shape. No, you don't, that's false accuracy.

I can give you two metrics to help illustrate this. In the AOs, we ask for the proposers to provide a schedule for building the spacecraft, which usually spans four or five years. I worked with an intern a few summers ago, and she had looked at old proposals and got this data. Back in 2008, the proposals we received then for New Frontiers, their schedules were about 20 lines long, 20 rows long, 20 IDIQs [indefinite-delivery/indefinite-quantity] in their schedule. For the AO we released in 2017, the schedules were, on average, 1,200 lines long.

JOHNSON: Oh my gosh, that's a lot of detail.

NIEBUR: Yes, and the proposals submitted later did not do 1,200 times better in terms of performance after they were selected. So that's where you have to ask yourself, it costs a lot of money to develop a schedule that's 1,200 lines long, are we getting sufficient value for the money we're spending on that level of detail? The jury's still out on that, but I really don't think that we're seeing that improvement.

Then the other thing you have to watch out for is what you said, that things change. Well, actually, let me give you another metric, too, in addition to the schedules. Nowadays, when a Center puts together a proposal to the Discovery Program, they usually end up having to spend $4 to $6 million of their own money to put that proposal together, and that's unofficial, we've never been told that number in detail. For a New Frontier's proposal, I'm told it's closer to $10 million. So if [NASA's] Goddard [Space Flight Center] is going to submit three or four or five proposals, that's a lot of money. Again, NASA has to ask itself, are we seeing sufficient value for that expenditure? To first order, I think to a certain extent the answer is yes because our cost performance has been going down with time. On average, the missions we select more recently are not overrunning as much as the missions we selected 20 years ago, percentagewise. It would be tempting to attribute that to the higher fidelity proposals that we're getting in. So in that case, you can say, yes, NASA is getting benefit from people spending $4 to $6 million putting together the proposal. But you also have to ask yourself the question, is that cost performance improving because of more detailed proposals or because just overall, we are all getting better at pulling these missions together? We don't have an answer to that.

JOHNSON: Yes, I'm not sure how you could get an answer for that.

NIEBUR: We have done some studies on that. SMD [Science Mission Directorate] has done some studies most recently. Back in the late '90s, we did something called the Skinny AO Study and then we repeated it about five years ago. Essentially what we did was have people who proposed do a regular AO and then tell them, "Here's a skinny AO that we ripped a lot of content out of. Take the proposal you submitted to the regular AO, rip out the corresponding content that matches the content we pulled out of the AO, and resubmit your proposal. We will reevaluate it, and then we'll compare the evaluations for your original proposal versus your skinny proposal." So look at what a regular AO produces and what a skinny AO produces. If the evaluations are the same, then that suggests that, at least for the selection process, thicker proposals are not adding much difference than thinner and cheaper proposals.

JOHNSON: Once those proposals are submitted and I'm assuming you're still part of that, of choosing those missions?

NIEBUR: Yes.

JOHNSON: Talk about that process for New Frontiers, who is involved in helping to select those missions and the process working through the different phases before they get to final selection?

NIEBUR: Yes, we do have a standard process that's used, but we can tailor that and customize it for any given AO, but the general process is that it's a two-step process. The first step is everybody submits their proposals and then the program scientist puts together a panel of scientists, and essentially for simplicity's sake, we'll call it a panel of engineers and the panel of scientists. They

work separate from one another, and the scientists evaluate the science value and science risk of the mission in the proposal, and the engineers evaluate the technical feasibility and risk and cost of the mission that's being proposed. They write up their findings and pass them back to the program scientist and the program—and I'm skipping over a horrendous amount of detail in how the program scientist has to populate those panels and monitor them and manage them and make sure rules are followed, it's a big lift.

But once they're done, they pass on their findings to the program scientist, and then the program scientist has to pull everything together and work with, in my case, the Planetary Science management, the division director and the deputy, and figure out which of these do we want to recommend get picked? That's an exciting part of the job, but what it means is you are integrating a huge amount of data in your head. And then trimming it down and presenting it in a way that managers, who haven't been living with this every day for two years, are going to be able to quickly ingest and understand your recommendation and support it, or as often, rip it apart and suggest something else.

But throughout this whole process, the program scientist has to have all this information in his or her brain because the other people at NASA Headquarters, they don't have access to the proposals, they're not allowed to. So if they have other questions about what is this mission doing, what does this instrument do, what are the science goals, the program scientist has to have all that in his or her head and readily available. If you've got four proposals, that's fine. We usually have between 15 and 25 proposals.

JOHNSON: Oh my gosh.

NIEBUR: So you pull together all that information, you come up with a recommendation that the division director approves. Then you have to go to a selection meeting with the associate administrator for SMD, and you spend three to six hours going through all this information, sharing your recommendation, and then justifying it in front of intense probing, shall we say, from the associate administrator, his or her deputies and management team, all the other division directors from the science divisions in SMD. So for Planetary Science, the Heliophysics division director is there, the Astrophysics division director is there, and they're not quiet. They're not just sitting there twiddling their thumbs thinking this is all about planetary, I don't really need to care about this. No, they're also vigorous participants.

JOHNSON: They just have things to say about the proposals themselves?

NIEBUR: More about the findings from the review panel because they're not going to weigh in on the science because that's not their field. But they all have extensive experience managing the construction and flight of space missions. And so you might get things like, "Have you really fully considered this aspect, of the complexity of this?" And, "I don't think you're going to be able to overcome that technical challenge in the schedule being allotted, why do you think that that's okay?" It's up to the program scientists to arbitrate between what the experts on the review panel think, what the proposers themselves think, and then what the senior managers at Headquarters are asking about as well as they bring their experience to the table. So you're right back to that opening comment of when you're a program scientist, you have to be able to switch, communicate between fields effectively and efficiently.

JOHNSON: Does New Frontiers select the way Discovery does as far as a down select?

NIEBUR: Yes.

JOHNSON: Okay, so somebody may get selected to be a finalist and then they go to the next step from there?

NIEBUR: Yes, so thanks for pointing that out because I mentioned there are two steps. What I just described is the first step, and then usually out of the 15 or 20 proposals we have, we will select two or three of them to proceed into our very imaginatively named step two. At step two, NASA actually gives these two or three teams money. We usually give them three to five million bucks and we say, "Great, now, further mature your mission concept using this money we just gave you. You have 6 to 12 months to do it, here's some money to do it, here's a list of the things we want you to be able to have good answers to."

And then at the end, they write up what's called a concept study report that is usually about 800 to 1,100 pages long. Then the program scientist does that whole evaluation thing again, gets another panel of scientists, another panel of engineers together, they give it a thorough review. They actually get to meet face-to-face with those two or three teams and ask them questions, which is very effective, but very complicated to manage because there are federal procurement rules that have to be very strictly adhered to when you have that kind of face-to-face interaction in a competitive process. Again, it's up to the program scientists to make sure those rules are being properly followed and documented.

So you do that review, which culminates in a face-to-face interaction, and then you do that whole selection process over again.

JOHNSON: When you do the face-to-face, that's usually at the site, right, of the proposer?

NIEBUR: Yes, we call those site visits, and what we essentially say is the evaluation team is going to visit you for 8 hours, not 7 hours and 55 minutes, not 8 hours and 5 minutes, 8 hours. You can do whatever you like with that 8 hours. We can sit here and do nothing, or you can take us to a parade or a tour of your facility. Or what we really encourage you to do is spend the bulk of that time answering the questions that we've given you ahead of time, the questions that we have about your proposal.

JOHNSON: Okay, so they have that upfront?

NIEBUR: Yes, they have that upfront, and they have chance to put together answers. They almost always squeeze in maybe an hour for a short tour, so they can show you some of the technologies that they're already developing for the mission because that goes a long way to retiring a risk and increasing confidence. But the bulk of that 8 hours is, we provided you the exam questions ahead of time, it's like an oral exam for your PhD thesis, except you get the questions ahead of time. We will all sit in this auditorium, the 90 of us, and listen to you verbally answer all of these questions. Each question has an ID number, each sub-question has an ID number, each question that comes up as part of the discussion gets an ID number and has to be tracked, all the answers get ID numbers and have to be tracked. That's when the paperwork starts to get a bit overwhelming.

JOHNSON: Yes, I could imagine. I know from talking to some of the folks with Discovery in the program level, meeting the teams was always something that helped with that decision because they look for things in the teams themselves and how they interact and who does the most talking and that sort of thing. So it's the same thing with New Frontiers?

NIEBUR: Oh yes. It is, but you have to be very careful how much you let that influence the review. Because if we ask you, "What's two plus two?" and you get up in front of the evaluation panel, and with the greatest serenity and confidence in the world, you say, "Two plus two is five," you're still going to get a major weakness no matter how wonderful your interactions with your team are, no matter how confident you are, two plus two does not equal five. Of course, it's never as simple as that, but you have to be on guard to make sure that the team's confidence—and frankly charm isn't blinding you to being objective, objective and critical assessors of the readiness of this team and of this proposal. The program scientist spends a lot of his or her time being on guard for that.

JOHNSON: Yes, I would imagine you do have to watch for that because sometimes people are more charming than they are effective.

NIEBUR: Well, yes, and then also when the evaluation teams are privately deliberating as a group, you have to watch out for it then as well because everybody has unconscious biases. It's the program scientist who's present for every second of that private discussion for both evaluation panels whose responsibility is to make sure that every single panelist is holding every single proposal to the same standard.

I think the greatest compliment I have ever gotten in my career at NASA was at the end of the engineering panel meeting, they spent two weeks meeting together. And at the end of those two weeks, one of them walked up to me, and he said, "Hey, Curt, I got to say, when we started this two weeks and we're talking about the findings for this one proposal and you pushed back and you said, 'Hey, you're not justifying this finding, and you've got to really convince me that there's a rationale to you citing this as a weakness.' And I thought to myself, oh boy, here we go, Curt's trying to influence the process to make sure his favorite proposal wins.'" He said, "And then we got to the next proposal, and you did the same damn thing, you pushed back on this and made sure everybody's treated the same." He said, "I just really appreciate that you did that," and I thought I will never get a better compliment than that.

JOHNSON: Yes. That brings up another question I wanted to ask about, and I know Susan had a lot of interest in this and tried to help with this. But there's not a lot of diversity in the science at NASA as far as women or not just with women, but also with racial diversity. But specifically, I know she was working toward getting women scientists and coordinating a lot of that. I did read that in the AO, I guess it was May 4, 2017, the New Frontiers AO included actually a call for more inclusiveness in those teams. Was that the one for Dragonfly?

NIEBUR: Yes, yes, I wrote that.

JOHNSON: Okay, talk about that for a minute because I know you can't force people to have a certain percentage of minorities or women in these proposal teams. But how do work toward that in a field that's traditionally been very much male? I think, I can't remember what the statistic

was, but it was pretty low for having women. What was it, 15 percent I think is what it was, the planetary mission team?

NIEBUR: Fifteen percent was considered success, which is complete garbage.

JOHNSON: Yes, so, talk about that for a little bit and how do you promote that, how do you get people interested in that and working toward that?

NIEBUR: In two ways. You said you can't force people to have quotas, percentages. All the studies show that that's not good, but I can sure as hell shame them into looking in a mirror and realizing that they lack diversity. That's why I wrote that language because I was getting tired of being told, "I have my Black friend on the team, so we're good to go." No, that's not, that's tokenism, not diversity. And so I wanted to send a clear statement that this isn't a rule, it's not a requirement, it's just something we expect you to do as a decent human being and a solid member of the community. So that's the first part of it.

The second part of it is making sure that that diversity exists in the community at large so that the PIs have diverse people to choose among. That gets more back to what Susan was doing with blazing a trail to get, at first, women and then broadening it beyond women. Because what I heard from PIs all the time was, "There aren't enough incredibly capable people in the expertise areas I need that are also diverse." It's like, okay, that's a legitimate concern because I know that, ultimately, you want the best team possible because you want to win. Okay, so I'm making diversity be a big component of increasing your chances of winning, but I hear you that you need the right people. Now, let's set aside the fact that those dozens of universities who have been

getting government funding from NASA for the past 50 years to do planetary science research have utterly failed to diversify the field, which is a stated goal of all those universities. Let's not overlook the fact they failed, but let's also not overlook the fact that NASA has been a passive organization in that process.

So NASA needs to get more active in increasing the interest among a diversity of young, budding scientists and engineers to go into space. It's been very gratifying, the last five to seven years, to see NASA step up and accept that we need to do more than just assume everybody else who receives money from us is going to address this problem. We need to be an active participant in addressing this.

JOHNSON: It's good to see actual improvement on that. I think Maria [T.] Zuber was the first woman to lead a planetary science mission.

NIEBUR: Yes.

JOHNSON: I know in looking for people to interview for this project, I kept looking for those female names. It wasn't easy necessarily to find, and definitely not as many as men, but I was glad to see some.

NIEBUR: Thank you.

JOHNSON: Yes, and as long as—as I said, my history, I started doing interviews with people from the very early human spaceflight and then, we really had to look for women.

NIEBUR: Oh, yes, they're not there.

JOHNSON: They were not there, yes.

NIEBUR: I can tell you that from my earliest days at Headquarters when I go into a meeting of significant size, more than 10, 15 people, because of Susan, the first thing I always do, figure out what percentage of people in the room are women. I'm happy to say that from my earliest days at Headquarters, it was maybe 10 to 20 percent, usually 10 percent. Nowadays, I go to big meetings, we're getting close to 50 percent, which is where it should be.

I think a lot of that is that there's been broad recognition of the fact that capable women are out there that can do this work and belong on these teams, as well as the fact that we're attracting and retaining more of them. So we're approaching success; we're not there yet. Now we need to duplicate that for all the other underrepresented groups. Every one of our meetings should look like a solid cross-section of the United States as a whole, that is the goal, that is where we should be. It shouldn't even be a goal, it should just naturally be happening, and the fact that it doesn't naturally happen means that there's something there stopping it from happening. Can NASA and our partners and universities fix all of that? No, because some of those barriers are beyond our control, but a lot of them aren't, and we need to be attacking every one of those barriers that are within our control.

Going back to Susan, when she was at Headquarters and asked, "Where's the nursing room?" people looked at her like she was from Pluto.

"What's a nursing—? First of all, what is that?"

"It's where mothers can go to express breast milk to bring them to their babies."

"Why would we need that at NASA Headquarters? Nobody here is of birthing age."

Sue said, "I am."

"Well, but we're not going to get one just for you."

"It's not just me, you've got nonscientists who are young women as well who would benefit from this. Stop and look somewhere else than in the mirror and realize that there's other people that exist."

JOHNSON: Yes, they weren't looking at the people that were answering the phones and making their appointments for them.

NIEBUR: Yes, you said you've been going over some other interviews. Did you ever run across anybody telling the anecdote of why during the AO evaluations, the engineering team now has a dress code?

JOHNSON: No, no.

NIEBUR: So when Susan left NASA Headquarters, she started working on those AO evaluation teams that were full of engineers doing the technical and management and cost feasibility assessments. These were teams of about 50 people, there were usually the same two women, and then they added Susan, and these were all essentially retired people, so good old boys' network is a great characterization of it. Susan goes to one of their face-to-face meetings, and she had just had her mastectomy because of her breast cancer, which is a traumatic experience for any woman.

She walks in, and there's four of the guys on the panel sitting in the front row wearing Hooters T-shirts.

JOHNSON: Ah, oh my gosh.

NIEBUR: They had just gone out to Hooters the night before to eat, and on a lark, they said, "Oh, let's buy some of these obnoxious T-shirts, and we'll wear them the next day as a joke." These are not bad men, I know all of them, and they're all solid people, they're not jerks, they're not misogynists, they just thought it would be funny. When Susan walked in and saw that, and then they saw Susan, it clicked very quickly to them, oh my God, we've done something horrible, and two things happened as a result of that. 1) By that evening in our hotel room, those four guys had sent her a big bouquet of flowers with a very heartfelt apology. And 2) NASA issued a memo saying, from now on, here's the dress code for these evaluation panel meetings because they didn't want anything like that happening again. Susan didn't ask for that dress code, but the program scientists in charge saw what happened and decided I do not want to run the risk of this happening again and somebody reacting a bit more stridently than Susan did and suing the crap out of us.

JOHNSON: Oh, no kidding, oh my gosh. That's an interesting story, thank you for adding that.

NIEBUR: Sure.

JOHNSON: Yes, I can imagine how embarrassed they would have been or at least I hope they were.

NIEBUR: Oh, they were. In fact, one of them is still around, he was on my evaluation panel for New Frontiers 4, sharp guy, really nice guy. In fact, he even brought up—this was boy, seven, eight years later. We were having lunch one day, and he just put down his fork to say, "Hey, Curt, I just want to say again, I know it's been a long time, that was really out of line, I really regret that we did that. We talked with Susan, and she said that she wasn't holding any grudges, but I just want to let you know, that was horrible of us."

JOHNSON: Yes.

NIEBUR: It's like, "Hey, it's been eight years, and this still weighs on you, you're a good person. You made a mistake, but you're a good person." I think for 90 percent of the community, that describes them perfectly.

JOHNSON: Yes, we're all human, and we make mistakes. Sometimes you just don't think.

NIEBUR: Yes.

JOHNSON: Well, let's talk about, you mentioned at the beginning that sometimes the AO but the decadal will come out with all these things that NASA may not have a budget to do, and then right after that, the budget magically gets cut. Talk about that and how that affects what you do. I know right now that's happening with the fifth AO as far as, for that to come out. I think the draft was out, but now, they've postponed it for a while, that that one's not going to come out until 2026, I believe?

NIEBUR: Yes, that is correct.

JOHNSON: Talk about that one specifically and how these budget cuts. Because obviously, NASA has no control over this, and we have administrations, and we have Congress, and all these other people that are involved in the NASA budget. And then things are going on now, well, we may be shut down by October 1st [Federal government shutdown if no budget agreement is signed],we don't know. So talk about how that affects spaceflight.

NIEBUR: Well, I think we have to be fair and acknowledge that a lot of the time, sometimes AOs get delayed because Congress has reduced NASA's budget. Sometimes AOs get delayed because our existing missions are overrunning, and we need money. The first place you always go when a mission overruns is you delay the next mission; that's just proper. You don't start the next mission until you have the current mission under control and in good shape. So back in 2012 when the previous decadal came out, that was very much a case of the former where Congress issued some pretty serious budget cuts to Planetary Science. We were the second lowest priority in the Agency. In fact, I remember the Administrator at the time meeting with Planetary Science Division, expressly to make clear to us, you are the second lowest priority in the Agency, deal with it. It was essentially, stop whining about this and accept that this is a reality and figure out a way to manage it, which I always thought was a very standup thing to do. So back in 2012, that was the situation.

In 2022, our first delay to the New Frontiers 5 AO, that was a situation of our own making. We had too much going on in the form of new missions that we had started. We just started two

Discovery missions, we had started a New Frontiers mission, we started a significant Venus collaboration with ESA, NEO [Near-Earth Object] Surveyor [Space Telescope] was started up. We ran out of money because we had too much going on. The second slip was more of a budget, overall government budget situation because of the debt ceiling deal. But, hey, it's fantastic that Congress dealt with that in a responsible way, but one of the consequences of that is reduced budgets for NASA and pretty much all other government agencies. We just simply have to accept that and deal with it.

But your question was essentially, how do you deal with it? I think the answer is you meet it head-on and from a very realistic perspective. Hoping for the best is not going to help you manage this, you need to sit down, you need to decide what are our priorities and what on that list is low enough that we can let it go? The difficulty with that is, a lot of times, politics makes implementing that list of priorities very challenging.

JOHNSON: Yes, I can imagine.

NIEBUR: Yes, as a hypothetical example, this hasn't happened, but frankly, if we announce tomorrow that we're going to slip the New Frontiers 5 AO from 2026 to 2028 because of budget problems, Congress could very easily come back and say, "No, you're not, we're not going to give you the extra money you need to keep it in 2026. We're just letting you know you're not slipping it."

"Okay, well, the reason we slipped it was because starting a new mission is at the bottom of the priority list and existing missions are higher than that. If you're telling us we can't manage to our priority list, then we're in difficult territory. We've got to move what's on the bottom of

the list now to the top because our stakeholders in Congress told us so. "Now, what's on the bottom, can we cut that?"

"No, we don't want you to do that either."

"Well, how about the one above that?"

"Nope, not that one either." I always say that it's great that everybody loves NASA so much. The downside to that is everybody loves NASA so much. It often feels like there's not a thing we do that somebody out there doesn't love.

JOHNSON: Yes, I know. Obviously, I have a job that has nothing to do with science. But I was at an appointment yesterday, and people ask you what do you do for a living, and you tell them you work as an historian for NASA, and their faces light up. Everyone loves NASA. They start asking questions. If I'd said I work for an oil company, I don't think I would have gotten that reaction, so I definitely understand what you're saying, yes.

NIEBUR: I have never told somebody I work for NASA and have them say, what a waste of money.

JOHNSON: Right, yes.

NIEBUR: They're always excited about it.

JOHNSON: They are, yes, but like you said, it can be a blessing or it can be a curse.

NIEBUR: I think most of the time, it's a blessing because let's face facts, this country provides NASA and Planetary Science in particular with almost $3 billion a year to do cool stuff with, it's a gift. And quibbling because, oh, it's 2.9 instead of 3.1, I get that that requires difficult decisions, but you're still being given $2.9 billion a year to do amazing stuff with. All the people in the country ask of us is please bring us along with you, so we can share the excitement. It's amazing.

JOHNSON: It is, Talk about that for a minute because that's one of my questions I have on the list is bringing those people with us as far as outreach and keeping that excitement out there in people so that they don't gripe about their tax dollars going to NASA. The education and outreach for these missions, how important do you feel that is for especially missions like this that are so budget dependent, not that they're not all that way, but like you were saying, you have to figure out how to do them within a certain amount of money, and you want Congress to keep giving you that money. You don't want failures if you can avoid it, but you also have to keep that excitement not just with Congress but with people out there in the real world. Talk about that how important that is.

NIEBUR: Well, I'll start by saying this is not a big expenditure. Our missions usually spend $1 to $2 million a year on this thing. So when people say, "Oh, it's too expensive to do outreach," I don't buy that argument. I would not characterize outreach and engaging the public as something that's important to do; it's just something we should do. It's their money; they're giving it to us because they want to come along with us. Bringing the public along with us on our missions is just as much an aspect of the mission as doing science. Until we get to the point where the science

team and the PI are self-funding these missions, the missions don't belong to them, they belong to the American public.

JOHNSON: Right, and I think getting that next generation to come in and take these jobs at NASA, it's important to keep people excited. Like the Lucy mission with all the videos and the cartoons and the things they had aimed at kids I think is a good example of that.[6]

NIEBUR: Yes, I mean, I'm at NASA today because of NASA outreach efforts in the late '70s to early '80s, and compared to what we do today, they were so incredibly limited. I would have to send an actual letter via the U.S. Post Office to a NASA Center to get them to send me back a pamphlet about a space shuttle mission. So the bandwidth was so much lower, yet it was still incredibly effective, I work for NASA today. Most of the people that I work with have the same story, I was fascinated about this stuff when I was a kid, and so I went into science, I went in engineering, and now, I work at NASA.

JOHNSON: Yes, having those posters in their schoolrooms and things like that are important.

NIEBUR: Exactly, and nowadays, we can do so much more and the bandwidth is so much greater. In fact, I think the Office of Communications people worry just as much about oversharing as they do under sharing. Because they're always concerned that if we build up people to a peak of

[6] Lucy is the first mission to explore the Trojan asteroids, first flying by three asteroids in the solar system's main asteroid belt, and by eight Trojan asteroids that share an orbit around the Sun with Jupiter.

excitement, how do we maintain that excitement for the eight-year cruise? So I know two years ago, I was telling them, "We need to really get everybody riled up for the Europa Clipper launch."

"Curt, it's in two years."

"Yes, think of all the great stuff we could do."

"Curt, how are we going to keep people to a fever pitch and keep them at a fever pitch of excitement for two years?"

"Oh, I don't know."

"Yes, we don't know either, so thanks for your enthusiasm, but why don't you let us handle this? We know what we're doing."

I was like, "Yes, that's a good point, guys, thanks."

JOHNSON: It's what they do for a living, right?

NIEBUR: Thank you, yes, not everybody else in the country is like you and looking ahead two years from now for the launch.

JOHNSON: Yes, people have short attention spans nowadays.

NIEBUR: Yes.

JOHNSON: Let's talk about some of the missions and that aspect of them, like the ones that are flying now, like New Horizons, Juno also, and OSIRIS-REx. There's always an extension, or it seems like there's always an extension to these missions. New Horizons, I think it's had—is it

two extensions now? The most recent one, from what I was reading, was a little different, but let's talk about this. The team or the PI, do they have to basically propose this? Because the money wasn't there to begin with, right, for these extensions of the mission, so does that have to be proposed and approved and everything again?

NIEBUR: To a limited extent, yes, and how we've managed this has changed over the years because, yes, until recently, you are correct, we haven't budgeted for these extensions. So what we began in the early 2000s was something we call a Senior Review. This was really just intended to make sure that the additional resources, including money, that are given to a mission that's extended, are going to be used to produce worthwhile science. Because take Spirit and Opportunity, Mars rovers, extending it, they're supposed to last 90 Mars days, they lasted 10, 15 years. But giving them the additional $15, $25, $35 a year they needed to just drive in a circle on Mars isn't a good use of money. But giving them that additional money for mission extensions to drive to Victoria crater, that huge impact crater, and learn new things, that's a good use of money.

So we started these Senior Reviews to give the mission a chance to talk to other scientists and say, "Here's the science we want to do," and then those scientists evaluate it and then give NASA their opinion. What that means is it encourages, if not forces, the mission team to stay diligent, to stay creative, to stay on their toes. Then it also allows NASA to be able to turn to our stakeholders, the Office of Management and Budget, Congress, whomever else, and let them know, we're good stewards of the tax dollars. Okay, you already spent 95 percent of the money it took to get this mission in place, and with the little bit of money we're now giving it, it's doing fantastic stuff, you're getting a huge return on investment. We're making sure of that with the Senior Review.

More recently, what we've started doing in the past three, four years is, I have to say, everybody has to acknowledge it, an extended mission is a gift. It is 100 percent a gift. It's a gift due to the generosity of the quality of the engineering that's put into these missions and the quality of the people building them. But you can't expect a gift, if you expect a gift, then it's no longer a gift, it's an entitlement, and extended missions are a gift. But we had to break this cycle of being surprised when a mission lasted long enough for an extended mission to occur and then scrambling to get the money. What we started doing in the past few years is from a budget standpoint, making sure we have the money set aside to pay for an extended mission. If the mission comes up with a good idea and the Senior Review says "Yes, that is a good idea." If those two things happened, then we've got the money ready.

JOHNSON: With New Horizons, was it that the Senior Review that they didn't think the Kuiper belt objects was a good idea or what happened with that?

NIEBUR: The New Horizons' most recent extended mission was a unique case because this was a situation where a planetary spacecraft had essentially finished its planetary mission. And then the chance of finding another Kuiper belt object to fly by, the estimates we were getting from the New Horizons team was maybe a 1 percent, maybe a 3 percent chance we'll find something. Okay, that's not a high enough chance for us to invest in this. So from a Planetary Science standpoint, the vast bulk of the science return and science potential of the mission has been achieved, it's a huge success.

There's still more science New Horizons can do, but it's Heliophysics Science, another division. So what we were trying to make happen was for there to be a seamless handover of New

Horizons from Planetary to Heliophysics just as we did with the Voyager spacecraft decades ago. They're still going strong and returning great Heliophysics science, but they're managed by the Heliophysics Division, not by the Planetary Division. So we're trying to reproduce that, and we did a very poor job of reproducing it. We just fumbled it completely, and I think responsibility for that can be very broadly spread, but as I often tell people, it may not be your fault, but it is your responsibility.

It was Planetary's responsibility to overcome that fumble and to get us back on the right track with New Horizons. So that's what we did about a year ago where we finally announced the decision, you know what, just the heck with it, forget everything we said, we're just going to keep New Horizons in the Planetary Science Division until 2029, we're done, end of story. The decision's made, we're just going to keep on going on like we've been going on, and that's what we're doing.

JOHNSON: All right, is Heliophysics helping as far as the management because of the science that's going to be done?

NIEBUR: It is a Planetary mission, and what we're working out with the New Horizons team right now is NASA wants you to do both planetary and heliophysics science. Here's your budget, you folks tell us what the right balance is between those two. You're aware of what planetary science is available for you to do and you're aware what heliophysics you can do, you know the resources, fuel, downlink, money that's needed to do it all. You optimize a good plan and share it with the mission program scientist, and if she's happy with it, just do it.

JOHNSON: One of the things I wanted to ask you about too is, the teams themselves when they come up with what they want to do, are they encouraged to look out there and look at other instruments or other off-the-shelf-type things to make sure that they can stay under budget? I'm thinking of instruments that have been used like on New Horizons and then again on Lucy, they used some of the same instruments. And a lot of that because if they're doing similar science, then they can use the instruments or readapt those instruments. Does NASA encourage that as far as trying to keep the cost down for these missions?

NIEBUR: We don't explicitly encourage that. What we do is, we encourage them, and by encourage, I mean, we mandate, you will stay within the cost cap when you submit your proposal, so adjust your concept accordingly. You can stay within your cost cap by using what we call high-heritage instruments, instruments that have flown before and proven themselves and are therefore likely low risk. Or you can stay within your cost cap by only flying one instrument instead of five, or you can stay within your cost cap by inviting magical fairies to build your spacecraft using magic that doesn't cost money. Any strategy you like is up to you, but we're going to have our science and engineering evaluation team assess the feasibility and the risk of your strategy. Now, the magical fairy approach is going to be labeled high risk, and you're not going to be selected.

The approach of using high-heritage, little-risk instruments has been widely embraced by the proposing community as a good strategy to get a good review and to be selected. But there's a natural tension there that we tell everybody the selection is based 60 percent on the quality and excitement of the science. So a little bit more than fifty-fifty, we give a little bit more weight to exciting science. That provides the natural tension needed, the encouragement to the proposers to not just fly the same thing over and over again, to do new and innovative things, to upgrade the

instruments, so they can do better science, and we can get better pictures, better data, or to come up with new, exciting instruments that have never flown before. There's various opinions out there as to how successful we are encouraging that kind of innovation and accepting the risk associated with it.

I can tell you that we had a technology symposium two or three years ago, and it was essentially a lot of technology developers came together, people who were coming up with new instruments and new kinds of solar arrays and stuff like that. I was on a panel, and they were essentially asking, "How can we get our stuff on to a New Frontiers mission?"

My answer was, "Engage with the proposers and demonstrate that you're of low risk, but high benefit, etc., etc."

They say, "Yes, but what about taking risks and being innovative?"

What I said was, "If you're going to be on a $1- to $2-billion New Frontiers mission, your technology must work, okay. If you want us to put a new solar panel on the spacecraft, it must generate electricity with a high probability of success because there's $2 billion riding on it," and I said a few more things.

After that workshop ended, SMD chief technologist reached out to my Division Director and said, "The feedback I got from some participants was that because of what Curt said, they're so demoralized, they're leaving the field."

JOHNSON: Oh gosh.

NIEBUR: "Because they're technologists, and they don't feel that they should have to develop things that have a 99 percent likelihood of success. It would really be great if you, the Division

Director, would write a community letter disavowing Curt and letting them know that they have the freedom to fail."

The Division Director who's Lori Glaze was just, "Yes, I'm not going to do that." In fact, I think what she said was, "We all know Curt has a certain style, and perhaps his style was off-putting to people, but the message is the appropriate message. But I do take that feedback to heart, and I think NASA does need to look for ways to bring in new, cutting-edge technologies and ideas on to our machine, absolutely. But we need to find a way to do that that's not going to endanger the $2-billion mission."

We've got a couple or three ideas for the New Frontiers 5 AO that one of them has been worked out, and I think it's going to be great. Another one came to me in the shower just a week or two ago, so that's got to be fleshed out. But I think we can accomplish low-risk, very exciting missions and take along high-risk, high-payoff technologies as well.

Going back to the AOs and how they evolve, we just need to modify the AO and do an experiment via the AO to try to find a way that we can make this happen. That's, again, one of the fun things about AO is they're evolving. Every AO is a new experiment in trying to make things better.

JOHNSON: Yes, I was going to ask you about that balancing risk because with Discovery, they're a little more risk tolerant because their cap is lower, and part of that is to encourage those ideas. Like you said, they don't have anything they have to follow, it's just anybody can come up with any idea and go for it. I also know, though, that the missions, the proposals when they're going through that process, they are looking for things that have that heritage or that are planning to use the heritage equipment or instruments and that sort of thing.

Because New Frontiers isn't as low cost, and like you said, you're having to balance that risk, and that's going to be every single mission, right? Even if they propose something that's new, you still have to balance that risk against failure because you don't want complete and total failure.

NIEBUR: I'm not sure I agree with you, and this goes back to that technology workshop as well and the conversation we had. No matter what the price tag of a Planetary Science mission, whether it's Discovery or New Frontiers or flagship. First of all, the price tag on the Discovery nowadays is a billion dollars.

JOHNSON: Right, it's gone up.

NIEBUR: So saying we're open to increased risk because it's only a billion dollars does not pass the laugh test, it's a billion dollars. Second of all, no matter what the price point of a Planetary mission, the level of public notice and attention it gets is such that if it fails, people are going to be upset and want to know why. That's why there's, what I call, the necessity of success for Planetary missions.

I hesitate to say this, but I will. When the Heliophysics Division launches a $200-million spacecraft to study the Earth's magnetic field and space weather, if it fails a month into the mission, it's a news article for a day or two. If Planetary launches a mission to Mars and it fails, there's a blue-ribbon congressional panel that looks into it. Frankly, the last time we lost a Mars mission, it was only about $500 million, but it fundamentally changed the way NASA does space science missions because of the level of interest and scrutiny from our stakeholders. That's why we have

the necessity of success because we know that any failure we have will be intensely scrutinized, both internally and externally.

JOHNSON: Yes, it definitely will be, I agree with you there, but I know that it's hard to grow or do those new technologies unless you're willing to take a certain level, accept a certain level of risk.

NIEBUR: Yes. The solution to this has historically been cost overruns because we'll select a new mission that's more cutting edge, has some technologies that aren't quite ready. And then about three years later when they're finishing up some of the technology development and start building it, they realize, ooh, you know what, it's harder and more expensive for us to finish developing this technology and get its likelihood of success up from 85 percent to 95 percent than we expected. Hey, NASA, would you prefer giving us another $30 million to get the success rate up to 96 percent, or would you prefer us launching with maybe an 80 percent chance of success on this instrument?

What we invariably say is, "Take 35 million instead of 30." That is the trade-off that we accept when we're doing hard things, whether that hard thing is an overall hard mission like Dragonfly, or a hard thing like a new type of instrument that's never flown before, or an enhancement over an instrument that's flown before. We always look at it from the perspective of if you need more money in order to be confidently successful, tell us, tell NASA Headquarters, and we will do what we can to help get you that money. Maybe it means we delay the next AO and the next mission, so be it. We want our mission to be successful because at that point, it's no longer the PI's mission, it's not JPL's [NASA's Jet Propulsion Laboratory, Pasadena, California]

mission, it's NASA's mission. It's the nation's mission, and we all want it to be successful, and if we have to sacrifice a bit to make it successful, then that's what we'll do.

JOHNSON: Well, there are some other things that could affect missions, and one of them happened to everybody around 2020, and that's the COVID[-19] pandemic. Some of these missions in Discovery and New Frontiers were at places in the mission that may not have been the best time for everyone having to go home. Talk about that time period and dealing with that. I think OSIRIS-Rex, it was an interesting time for them because they were going to be getting the sample, and a Lucy of course in Discovery, they were in the middle of everything. But talk about that happening and how that affected New Frontiers.

NIEBUR: Sure, well, let me say first that for people who work at Headquarters, COVID did not have nearly the huge impact that it did for everybody else. That's because for NASA Headquarters, on a daily basis, the people I interact with are not three doors down from me. The teams I interact with are scattered around the country, if not the world, so working from home and interacting with them on Zoom and Teams and on phone calls, that was just another Tuesday for me. But, yes, the impact on the Centers and on people, on teams that were putting together missions, yes, they're not all collocated, but a big chunk of them are. So it was a big change for them and a change that they had difficulty with.

Now being a Headquarters person, for me, this all comes down to what was the financial impact. I don't recall the numbers off the top of my head, but I think for Lucy, a Discovery

mission—it was either Lucy or Psyche, I forget which one, had essentially zero financial risk impact.[7] It must have been Lucy.

JOHNSON: It was, yes.

NIEBUR: Yes, they had zero impact. Psyche had a huge impact. Some people attribute Psyche's launch delay to COVID. I personally don't buy that, but some people do. Europa Clipper had a—it was like a triple digit million-dollar impact depending on how you—but it wasn't 800 million, it was closer to $100 million just due to loss of efficiency. So the impact varied quite a bit depending on what stage of development a given mission was in and also to a great extent, on the personality of the individuals on the mission. Because Lucy and Psyche were pretty much at the same stage, yet Lucy did fine and Psyche didn't, right? That's a fascinating study that somebody should do at some point as to why that happened.

But for the rest of New Frontiers, let's see, Dragonfly was just getting started up at that point. It very much slowed down Dragonfly's momentum to get started and to make rapid progress because the year after you're selected for flight is one of your two most productive periods. Because the momentum you've built up and the excitement you've built up just boosts your productivity like crazy. And Dragonfly got to that, and then they're all told, "Everybody go home and stare at your computer screens," and we completely lost that momentum, and that had long-term impacts. That's not even getting into supply chain delays, which I think are far more devastating.

[7] The Psyche spacecraft is traveling to a unique metal-rich asteroid with the same name, orbiting the Sun between Mars and Jupiter. Because of its high metal content, the asteroid may be the partial core of a planetesimal, a building block of an early planet.

OREx, see in that time frame OREx was—was OREx at Bennu when COVID started? I guess it was.

JOHNSON: Yes, and they were on the surface in October of 2020, so that's when it collected it.

NIEBUR: Yes. Off the top of my head, I don't recall being emotionally bereft at seeing assessments of what the COVID impact to OREx were, which leads me to conclude that they weren't as significant as Europa Clipper. And Juno just kept chugging along; Juno is the unstoppable Energizer Bunny.

JOHNSON: Yes, it's going to be around for a little bit longer, isn't it? When was it supposed to stop? Let's see, I got it written down.

NIEBUR: Two years ago was when it was supposed to die.

JOHNSON: Oh, yes. It was supposed to, but it should be around at least through next year, right?

NIEBUR: I think for the last two or three years, what I've been told is next year is likely the last year. I have been telling my superiors, "You should just plan, you should just lay in the budget for this, assuming it's not going to stop for quite a few years yet."

JOHNSON: That's amazing, like you mentioned before, just the engineering, this is a testament to the engineers and scientists that developed these. And going back to the rovers and lasting for years instead of a few months.

NIEBUR: Well, but it's also a double-edged sword because at the time these spacecraft were built, what the engineers are telling you is we are designing and building it such that if you need it to last for a year, we're confident it'll last two, so you have a factor of two margin. That's the general rule of thumb. The fact that they're lasting a factor of 10 times longer is, like I said, a gift but also a curse because what it also suggests is are we perhaps over-engineering these and are we too conservative? This is related to the new technology issue is like are we so afraid of failure that we overengineer them to the point that we are essentially spending too much mass, too much schedule, too much money on them?

I think there's a lot to explore there, but I think a lot of it is also just, as some engineers have told me, that the manufacturers of some of the components that they use don't have a firm understanding of when those components fail. We tell them we want this switch to operate 2,000 times, so they test it 4,000 times, and say it's fine. They don't keep testing it until it fails, they just make sure it meets their specs. It might last 40,000 times; they don't know that; they haven't tested that because we haven't asked them to do that. If you want, we could spend more money and do very targeted, precise lifetime testing on every single component, but that will probably cost you more than all of the extended missions that you fund. Okay, that's a persuasive business case right there.

JOHNSON: One of the things I wanted to ask you—and I like to ask everyone I've been talking to about this—is what do you think about this PI-led competition model for Discovery and New Frontiers programs.? What's the benefit of running a program this way and selection, and are there any downsides to this?

NIEBUR: I think it's fantastic. I think the approach of having open, as-transparent-as-we-can-make-them competitions and selections are fantastic. I think that we often lose sight of what a paradigm changer that was in the late '80s, early '90s when we moved to that paradigm. Because prior to that, it was essentially some well-placed person gets an idea for a mission and goes into a smoke-filled room with a handful of other well-placed persons, and the mission's born. And that works out really great for those handful of well-placed persons, but nobody else gets a say in that, and means that the best ideas never get considered.

We've structured a system where I won't be foolish and say any great idea can come forward, but a lot more great ideas can come forward and be considered. I think it's a huge improvement from the smoke-filled room, and I think we should always be grateful for it, and we should always be on guard for anything that might endanger it. Because it is very, very easy—and it still happens to this day—for an external stakeholder like Congress to simply dictate to NASA, "You will do this mission." If the mission they want us to do has great science support and a strong science foundation, that's great. What happens if it doesn't? This is not something that stopped occurring in the 1980s; it still happens today.

Europa Clipper, to a great extent, was mandated by Congress. We were fortunate that it's a great mission that we should be doing and we are doing, but there are other missions that I don't think fall in that category. Well, we're doing them because a powerful stakeholder makes us. I

think we always have to be on guard against one well-connected scientist or center director or somebody else finding the right person at Congress that they golf with and convincing that powerful congressperson put some budget language in that makes NASA give me the mission I want.

So, yes, I think an open, competitive process is great. I think PI-led missions are also great, but I think that they are incredibly unfair to the PI. Because what we tell this PI, who two-thirds of the time, is a university professor, is overnight they go from, I submitted a proposal to getting a phone call from the AA saying, "Congratulations, your dream has come true, we've selected your mission. Here's a billion dollars, and by the way, if anything goes wrong, it is completely your fault."

JOHNSON: Yes, some PIs are much better at running these missions than others. And I know that's a partnership and the program provides management from the Centers and that sort of thing, but it's quite a leap for a lot of these PIs that have come on.

NIEBUR: A leap with no training, the only training or experience these PIs have is maybe they've been a co-investigator in a science team for other missions, but they're not getting any formal training. They don't have any special education about how NASA works or how the congressional budget process works or how Center management works, and yet overnight, we essentially tell them, you are now empowered to walk into the office of the Goddard Center Director, the JPL Center Director and boss him or her around. That is not realistic.

JOHNSON: No.

NIEBUR: That is not realistic at all. And the number of conversations I've had with even Center employees, like project managers, much less university-based PIs who say, "Oh, we found a solution to this problem, here it is," and for me to look at them and say, "What you just asked me to do is literally illegal—"

JOHNSON: Oh gosh.

NIEBUR: "—it can't be done. At the very least, I will go to jail if we do that, you will probably go to jail with me," and I just get blank looks back like, "Why? All we're saying is you take money from five years in the future and give it to us now."

JOHNSON: The quite the way the world works.

NIEBUR: No, it's not. I love the idea of empowering a scientist to be in charge of a science mission, but I think both NASA and the institution that that PI comes from need to step up and do more to both prepare and support that scientist to become a PI and to be a PI. Because the University of Anywhere loves to put out press releases saying, "A scientist from one of our departments is in charge of a NASA mission, and therefore, we're a great university." But when I talk to that university professor and hear him or her say, "Yes, I've got to teach three classes this semester because I can't get a teaching waiver on my teaching requirement from the university, and so I have to work 80 hours a week between the NASA mission and teaching." It's like, "Well, that is not your university supporting you as a NASA PI."

JOHNSON: No.

NIEBUR: If they want to have the press release bragging about you, they need to do other things to support you.

JOHNSON: Have there been occasions when you had to have those heart-to-heart talks with some of these PIs, or find help for them, or even remove someone, or suggest that they step down and let somebody else take their place, or anything like that?

NIEBUR: Yes.

JOHNSON: I would imagine in your position, that might be something that you would have to deal with.

NIEBUR: Yes, they are never pleasant conversations. I will say the amount of personal passion that scientists, and engineers, and managers bring to the missions they're working on from the earliest days of the proposal to the last days of the mission, the personal passion that they invest is astonishing. This is a big part of who they are as people, not a big part of their careers, a big part of who they are as individuals, it's incredibly personal to them.

JOHNSON: I can imagine.

NIEBUR: That's part of the magic of NASA.

JOHNSON: Yes, it is, and imagine for some of the PIs, it's completely a dream come true.

NIEBUR: Oh yes, yes, absolutely. I haven't talked to a single PI whose response to the job has been, "Meh, okay."

JOHNSON: Yes, well, we're about 5 minutes away from our time, and so it's probably a good place to stop, but I do have a few more questions.

NIEBUR: Sure.

JOHNSON: I did want to talk to you about Europa, if we could, so if you would have time in the future. Are you going to be going to the launch next month?

NIEBUR: Oh yes.

JOHNSON: Maybe after the launch would be a good time to talk to you about Europa.

NIEBUR: Sure, yes, I'd be happy to do that.

[End of interview]