NASA DISCOVERY 30TH ANNIVERSARY ORAL HISTORY PROJECT
EDITED ORAL HISTORY TRANSCRIPT

MARK P. SAUNDERS
INTERVIEWED BY SANDRA JOHNSON
FOLLY BEACH, SOUTH CAROLINA – MAY 11, 2022

JOHNSON: Today is May 11th, 2022. This interview with Mark Saunders is being conducted for the Discovery 30th Anniversary Oral History Project. The interviewer is Sandra Johnson. Mr. Saunders is joining us today from Folly Beach, South Carolina, and we're talking over Microsoft Teams. I appreciate you taking the time to talk to me today for this project. I want to start by talking about your background and your education. I know you worked for the Navy for a while, but also how you first came to NASA.

SAUNDERS: That's a great question. I am the son of a Navy pilot, and so I grew up fundamentally on the east coast, so traveled between Rhode Island, Virginia, and Washington, DC. I was up in Rhode Island when NASA started back in the early '60s and got interested in the space program then. One of my science projects was a rocket patterned off of what we were building for Apollo. From that moment I was really interested in what NASA was doing, space, and all those things. Typical stuff for young people.

However, what I really wanted to do was be a Navy pilot like my dad, but I was color-blind. Being a Navy pilot was not going to happen. Instead of going to the Naval Academy, which both he and my grandfather had done, I went to Georgia Tech [Georgia Institute of Technology, Atlanta]. First started out in aerospace engineering, shifted more towards system engineering. It was a degree in industrial engineering, but with a system engineering focus. That was during Vietnam [conflict]. My draft number was 42, it's a long story, I won't bore you

with it, but I ended up joining the Navy, and going to Scotland. I spent three years on a Navy submarine tender in Scotland. The whole time that I was doing this I was not really intending to make a career out of the Navy. But as things work out, sometimes you end up following the path that life lays out for you.

After my active duty, I came back to the States and went to work for the Department of the Navy as a civilian engineer, while at the same time being a reserve engineer. My discipline in the Navy was what they called engineering duty. I was not required to really go to sea or do anything, but to help design and maintain the Navy ships. If you count my active duty and my civilian career, I worked for the Navy for almost 20 years, working for the Navy's Fleet Ballistic Missiles Program. That was the nuclear missiles. We maintained them while I was in Scotland, and then when I came back to the States, I started working on the submarine side.

But after about 10 years of that I decided—going back to what I said earlier about really wanting to get to NASA—I said, "I really would like to try to get back over and work for NASA, but before I do that I probably ought to get some experience in missiles," since I was working on the submarines. I went to work for the Navy's program office that managed the overall missile program. While I was there, I was responsible for managing two of the Navy's centers that built the missiles and outfitted them onto the submarines and maintained them.

After six or seven years of this, I went, "If I'm ever going to go to NASA, I best get on it," and started looking at whether or not I could ever get over to NASA and started applying for jobs. Getting into NASA was a little more difficult than I thought. It really turned out that my Navy connection with a fellow on Space Station [Program] opened the door for me. After almost 20 years of working for the Navy, I transferred over to work on the International Space

Station. That was in Reston [Virginia] at the time. There's a later question that you ask about what I learned from all of this as I got closer to Discovery.

When I went to work for NASA, I had assumed that the culture would be different than it was in the Navy. I was not quite prepared for how different the culture actually was. But working on Space Station, this was a time when the Space Station Program office, was in Reston. I don't know if you were working for NASA back then or associated with it, but as a result of the [Space Shuttle] *Challenger* [accident] investigation and the Rogers Commission, they put the program office for Space Station outside of a NASA Center, so a NASA Center couldn't influence it. But that was so anticulture for NASA that that program office didn't stick. I was the Logistics Manager for Space Station, eventually went up to work for the Program Manager, as we tried to convince Congress that terminating the Reston Program Office was not a bright idea and sending it back to Houston [Texas, Johnson Space Center] was going to cost a lot of money. It didn't really matter, because if you remember, during that period Dan [Daniel S.] Goldin was the [NASA] Administrator. He hated the program office. There's lots of rumors about why he hated the program office, but he was successful in killing the program office and shipping the program back to Johnson Space Center.

When that happened the employees in the program office were given an opportunity to go around NASA Headquarters and the centers to see where they wanted to transfer from the program office. I started talking to the people in the Office of Space Science and had really two opportunities. One was to go to work on Discovery, and the other was to go to work on the upcoming missions to repair the Hubble [Space Telescope] with the Shuttle. One of the attractive things about Discovery—and this is coming back to a question that you asked—was that Discovery was implementing a new procurement process. One of my jobs in the Navy was

heavily procurement oriented. I negotiated the technical contracts every year, both for annual contracts as well as procurement contracts for systems. I had a lot of experience in procurement and Discovery was entering that phase, and so I said, "This looks like a lot of fun anyway." That's why I chose Discovery.

When I transferred that was at the end of 1993. I'd been on Station from the end of '89 to the end of '93. Then transferred to the Discovery Program Office. I'm going to cover a little history of Discovery in just a second. I was hired by the Office of Space Science to be what they called the Discovery Program Engineer. It was the technical person on Discovery. There was a program manager in the Office of Space Science at the time. Her name was Mary [E.] Kicza, and I was going to be her technical support, and I was going to be the mission manager for Mars Pathfinder when I took that job.

About two months, maybe three months later, I can't remember, Sandra, Mary was promoted upstairs to the front office of the Office of Space Science. They promoted me up to be the Program Manager of Discovery. At that point we were developing the first announcement of opportunity [AO], which was the first solicitation for the first competitively procured missions for Discovery. The state of the announcement of opportunity was I'd say about 60 percent. We were working on the program plan, we were working on the evaluation plan, trying to get that ready. That's when I took the program over.

But I want to back up a little bit and give you that while I was working at Space Station there were things going on in the Office of Space Science that led to the Discovery Program, and I wanted to cover a couple of those things, because I'm not sure that any of the people that

you've interviewed would remember all of this. I will tell you that Mary and I and a fellow named Richard Vorder Bruegge wrote a paper.[1]

JOHNSON: I did find it.

SAUNDERS: That covered a fair amount. Since you've read the paper, I'll just cover some of the important aspects of it really briefly for the history.

JOHNSON: Right, because I do want your perspective of that. Even though it's written down I want your perspective. Thank you.

SAUNDERS: I've got some funny stories to add to it too. That'll make the oral history a little bit more entertaining.

JOHNSON: We love the stories.

SAUNDERS: In the early '90s NASA began to realize that the bigger missions that they were flying were taking a long time and consuming all the resources, and that there were these big gaps in between mission implementation where the planetary science community didn't have any missions to work on or mission science data to collect and analyze and draw conclusions from. They got worried about that, this is covered in that paper, and decided that maybe they needed to

[1] *Discovery Program Overview*, American Institute of Aeronautics and Astronautics (AlAA) Space Programs and Technologies Conference September 27-29, 1994

think about doing something a little bit different and maybe implementing some smaller missions.

What's not in the paper, but what was happening at the same—let me just get the timeline. That was the early '90s. By '92 a lot of the word had gotten out that NASA was really interested in this. The Senate actually put some appropriation language in there that NASA really needed to think about smaller missions. NASA responded to that in April of '92 with the first set of concepts around the Discovery Program. Followed that with two workshops, one in San Juan Capistrano [California] and then a follow-on one that talked about management, where they were evaluating whether or not there were decent concepts that could actually fulfill the structure around—I'll come to that in a minute—the way we were thinking about Discovery at the time.

Those all led to NASA funding 14 what you would call prestudies that said, "Take these." Out of those San Juan Capistrano 14 studies were funded for initial concepts. They were presented to NASA at the time that I was the Program Manager in '94 just before we released the AO, and they came back and showed us how their concepts would actually fit the model that Discovery was thinking about.

But to develop that concept NASA hired a bunch of what we all called graybeards. That included Jim [James S.] Martin, who had been the former Viking Project Manager. Frank [A.] Carr out of Goddard [Space Flight Center, Greenbelt, Maryland] and a couple other people, I can't remember their names, to evaluate the management structure and the approach to the solicitation.

The real credit for this approach goes to them. They were the ones who developed this. You would have to ask Mary, because I never really asked Mary when she started on the

Program, Mary Kicza. But Wes [Wesley T.] Huntress was the AA [Associate Administrator] at the time. They worked with Jim and Frank and the others as they put the meat on the bones around a concept of acquiring a whole mission. Rather than the way that NASA had been traditionally doing it, where you would fund a concept and then fund the predesign work and then fund the actual preliminary design, all separate. They had come up with a concept where you would do it all at once.

If you remember in the paper, they were also talking about really encouraging industry and universities to get more involved. This all tied together in a way in which it was putting the pieces in an interesting puzzle together that met a lot of the criteria that both Congress and NASA and the science community all felt would benefit everybody, really looked like a super win-win perspective.

I get no credit for coming up with that. What I feel I get credit for is that I took that and made it happen. Forgive me, I try not to blow my own horn, but I really felt I was the right person at the right time. I had all that technical procurement experience at the time that they were getting into the procurement phase and felt that I would add some value to that. I think that that worked out. If I looked back on my life and said, "What is the one thing that you are most proud of?" Discovery Program is it. I feel very happy that I was able to be part of it.

That takes us up to the present time. When I say present, when we were finalizing the announcement of opportunity, the evaluation plan. I'm going to get into one of these funny stories for you. At APL [Johns Hopkins Applied Physics Laboratory, Laurel, Maryland], I think it was every spring, APL would sponsor a small satellite conference. It was in April or May. I can't really remember it. I had only been the Program Manager for a month or two, was heavily working on trying to get everybody at Headquarters linked up on how the AO was going to

work, and went to the conference. I sat in the back of the room and just listened, because I'd been a Navy guy and human spaceflight guy if you count my four years on Station, so I was in major learning mode.

Jim Martin, who found out that I was the Program Manager now, came over and sat down next to me and introduced himself. He's a big man by the way. He was a big, tall dude, and said he'd like to come downtown and talk to me about the program. I said, "God, Jim, that would be wonderful."

I'm not going to use the language that he used. Jim came down to see me at Headquarters after that conference, walked into my office, and said to me, "Mark, you are screwing this program up."

I went, "Okay, go ahead. Tell me what's going on." At the time the evaluation plan—I want to restate something. I came out of DoD [Department of Defense], so DoD, we typically issued requests for proposals where you asked for specific things. The evaluation plans for RFPs [requests for proposals] are very detailed and very quantitative. You get 40 percent for this criterion, you get 30 percent for this criterion, whatever. Numerical scoring and lots of numbers.

Jim goes, "Your evaluation plan is geared after DoD approach." It was developed before I got there, but I was very familiar with that approach and very comfortable with it. He said, "Based on that plan you will end up selecting a mission that's unachievable." He gave me an example. He said, "If the mass margin of the vehicle is too small when you pick it at this concept phase, it will be way too heavy." This happened by the way. "It'll be way too heavy when you get to the launchpad and it'll just sit there and rumble and it won't get off the launchpad. Your plan does not account for that singular flaw in a proposal because you've

weighted it at a small amount. You need to change this plan and you need to get an evaluation team who is capable of understanding these things."

The evaluation team was already put together. I looked at Jim and I went, "Wow. Okay. I see your point. I'll have to think about this." I created a new problem for myself, which I'll come back to later in the dialogue, because these are funny stories. I formed another team. Now I had two teams. I had this team that was led by SAIC [Science Applications International Corporation], very detail-oriented, perfectly adapted to the DoD style approach, which Jim said would be a disaster, and I accepted that. I formed another team with Jim as the chair of it, and it was about 10 people out of both NASA and DoD. Jim Martin, Marc Bensimon from Space Station, Al [Albert R.] Schallenmuller who was a previous ops guy, Gentry Lee if you've ever heard of Gentry Lee, famous guy at JPL [Jet Propulsion Laboratory, Pasadena, California]. Whole bunch of graybeards that knew how to build spacecraft. They were all either Viking or previous missions.

I had two separate teams now that were going to evaluate these proposals. We were going to take the information and combine it, I'll get to that in a minute, to try to solve the problem that Jim laid out for me. We then finished the draft AO, issued it out to the community. Community was very gracious in responding. They found plenty of flaws in the AO. We tried to correct those flaws, and then issued the AO in August of 1994. We got 28 proposals back and then began to evaluate them.

Then I bring these two teams together at LPI, which is down in your neck of the woods, Lunar and Planetary Institute [Houston, Texas]. I've got these two teams. Jim, God rest his soul, he's not with us anymore so he can't beat on me. He became my mentor by the way. Love the man. He was temperamental though.

I got this highly detailed group that did all the little numerical stuff, and lots of piles of data, piles of data. Jim Martin with one sentence. Mass is not adequate. In a room with the scientists. We did the whole evaluation all together in a room. I was clueless about how the science community worked. That was an education. But Jim Martin and the head of the other little team, they got into a huge fight. Huge fight. I had to stop the meeting. I had to get everybody out. Everybody's going to walk out, go home. I'm going, "Disaster." But we got everybody calmed down and we got through it.

The interesting thing about that process was Jim Martin and his team found the really big issues, the ones that were—and there were missions that had the mass problem, 5 percent launch mass at launch on the pad starting today off by 30, 40 percent. All the detailed analysis. I had everything. It really worked out. I'm going to come back and talk about Mars Pathfinder and NEAR [Near Earth Asteroid Rendezvous] in a minute because I failed to talk about that. But we then went into the NASA Headquarters process. We took all that data, documented it all, went up. There was a person named Dave [J. David] Bohlin in NASA Headquarters who managed this process for the Office of Space Science. He was very good at it, very precise, and helped us present the information. It went before a board that categorized the missions.

Before I get to that. I'm in this room with my two teams and all the scientists who evaluated the science on the proposals. I made everybody vote. I don't know if you've worked with the science community. Putting them in a room and making them vote like that with engineers is really—they're sitting in their chairs, and they're squirming around. I had no clue what I was doing. I learned that the science community thinks differently. I want to tell a couple more stories because they're related to why this particular solicitation and the way the evaluation plan was laid out with this quantitative approach worked for the first solicitation. Al [Alphonso

V.] Diaz, who was the Deputy at the time of Office of Space Science, said to me, "You better pick a small mission." When he said small, he meant small, little, as in doesn't cost very much money.

I'm going, "It is going to be what it is. I am not going to fudge the books." I didn't tell him that, I just hoped for the best. Lunar Prospector, which was the first mission that we competitively selected, was proposed at $59 million, and its science was rated very good. Not fully understanding how the science community thinks, very good is not a good response. If it's not excellent don't fly it. But because of the way the math worked on this thing, Lunar Prospector ended up at the top because it was so small. It actually got picked. I had Steve [Steven W.] Squyres, if you've heard that name before. He reamed me out. I'll come to the debriefs in a minute. Something happened in the debriefs that I think is important to the way Discovery has worked and where some of the issues are today. Lunar Prospector got picked, and I didn't have to fudge anything. I wouldn't have done it anyway. It's just not something I would do.

We took all that forward. Lunar Prospector was picked. We picked a second mission after some discussion and debate, which was Stardust. The two got picked in that first solicitation if my memory serves me correctly. I think it does.

Afterwards I held—I'm jumping around. I'll fill in things. I'll go back to Mars Pathfinder and NEAR in a minute. Afterwards, I went, "We need to sit down with the community and decide what went well, what really didn't go well, and make some adjustments to the program," so that it more matched what the community wanted and needed, which was consistent with what NASA wanted and needed as well.

My personal view of my job at the time was I'm a facilitator. I'm facilitating NASA and the community doing the science. What I need to do from a program perspective is to implement a program that meets your needs. The point of the lessons learned workshop was to find out where we did well and where we didn't do well and then make some adjustments.

We had an all-day, might have even been more than one day, I can't really remember, workshop in DC where everybody came, made presentations, made lots of recommendations. What was interesting was the recommendations were conflicting. I got some recommendations to do it this way, some recommendations to do it that way. I formed a very small group of about four or five people. [G.] Scott Hubbard from Ames [Research Center, Moffett Field, California], a lady from Lockheed [Martin, Corporation], a person from JPL, Gregg Vane, one or two other people, to try to sort through, put together a package, recommend it to the Office of Space Science, on ways in which we might consider changing.

At that time, the proposals that we got were probably about that thick. They were huge. We asked for a lot of information and we wanted to be able to—I'm going to come back to this in a minute on why I think the program worked so well—we wanted to be able to have a really good understanding of what it is that they're planning to do and how they were going to approach it, so that we felt confident that they could actually accomplish that in the box that we had built for them. I went around and asked many of the proposers afterwards in one-on-one conversations—as an example I went to see Noel [W.] Hinners at Lockheed and said, "How much did it cost you to prepare these proposals?" so that I had some sense of what people were spending. The average cost of a proposal was $1.5 million. Now I'm going, "Wow." This was 30 years ago. I'm going, "That's too much money."

It was at that point that we started thinking about breaking this process up, reducing the amount of information that we asked for up front, going through a process where you really focused more on the science and only on the very top-level feasibility of it, and then having a second step where you picked a couple of those. That's called the two-step process, which is the process we use today. Then asking for the complete package of what would be typical for a classic Phase A to reduce the initial cost for the 28 or 30 proposals. That seemed to take some traction, and we ended up doing that and moving to a process where we had a two-step process. I was happy about that.

As you know, Mars Pathfinder and NEAR, both the first two missions, there's a debate between the two organizations, APL and JPL, about who was number one. One landed before the other, one launched before the other. They're always competing. There was a competition for NEAR between JPL and APL when NASA decided to ask APL to do the NEAR mission.

Both of those were directed, and they were both in the process of development when I took over the program. Mars Pathfinder, I did both the program manager job and the mission manager job for Mars Pathfinder for a long time before I felt it was just too much. I was neglecting my program duties to manage Mars Pathfinder.

They were directed missions. NASA picked them, said, "You go do that. We'll kick off the Discovery Program with these two missions." They were very successful, as you know. I think Mars Pathfinder came in at like $277 million. There was a lot of debate about all the manpower that JPL put into it that's not accounted for. But it doesn't really matter. Mars Pathfinder was very successful. If you've ever watched *The Martian*, [2015 movie adapted from the book by Andy Weir] Mars Pathfinder is what Matt Damon goes and gets.

NEAR was also very successful, although they missed their first flyby of the asteroid and had to go back and come back around. But that was very successful and they did something in that mission that was important for the future of Discovery. APL decided when the mission was over to land NEAR on the asteroid. That proved the capability that you could actually land on a small body. That was pretty significant.

After we did that, we started working on the next AO. I'll just cover a couple of points about Discovery that I think were important to the community at the time and important to NASA. The missions were capped at $150 million in '92 dollars at that time, 35 months of development time in Phases C and D, from PDR [preliminary design review] to launch was 35 months max, 36 months if you add the month of commissioning after launch. These were agreed to by Congress as part of the congressional approval of the program.

Shortly after I took over, and I don't remember exactly when this happened, Discovery got its own line in the budget. We could do a little bit more planning with that. Lunar Prospector, we made a mistake in the solicitation. We were unclear about fee. The $59 million that Lockheed proposed for Lunar Prospector didn't include fee. I went, "Bad on us." Fee is important, so you get fee, so we upped it a little bit to cover their fee.

Scott Hubbard really worked with Lockheed. Scott was at Ames at the time, so we assigned Ames as the managing center for Lunar Prospector because Ames is just right around the corner from Lockheed in Sunnyvale [California]. Scott negotiated a contract that's never been negotiated before, a 100-0 incentive fee. From the incentive part, Lockheed was giving up. If they overran, they were going to eat 100 percent of it. I went, "Wow, you're the man."

I negotiated the fee structure for Stardust. That was an interesting experience for me personally, and I just relayed this to a good friend of mine just the other day. I was used to the

DoD style of contract negotiations. You take your calculator, you get pissed, you throw it against the wall, lots of acting and shouting and quite adversarial. I was out at Martin at the time, they were in the process of merging if my memory serves me correctly with Lockheed, to negotiate their fee structure. The head at Martin looked at me and he said, "I don't understand what you're trying to do with this. Can you explain to me what you want?"

My experience was, "Oh no no, you don't have that kind of conversation with somebody because they'll just use it against you because it was a constant conflict. By the way when I say conflict, we would all go out and go drinking together afterwards. It was never personal. But this was a new experience for me to have them go, "Well, just tell me what you want." I sat there for about 30 seconds and I said, "Okay. I'll see how this goes." So I told him exactly what I wanted.

He went, "I don't think your proposal will work to give you what you want. Here's why."

He explained it to me, very similar to what Jim Martin had done to me, and I went, "Oh. You're right."

They said, "If we do it this way, you get what you want."

I said, "Perfect, thank you."

I'm going to change the topic just slightly because this is something that I think is a bit flawed in the program today and I want to tell you what happened in that first set of proposals. After we did all the evaluations, made our selections, we offered each proposer a debrief. I was instructed by my management in the Office of Space Science to give them nothing and to tell them nothing. Just tell them, "We picked this and you didn't meet the criteria so we didn't pick you."

I went, "No. That's not kind, that's not fair, that's not courteous, and that's not helpful." But I was directed not to do that. I went, "Well, that's not what I'm going to do. They're going to have to fire me."

I sat down, I couldn't give them anything, because that really would have got me fired. I sat with them. I took two hours for every debrief. I spent 30 minutes telling them how we did the evaluation so that they had confidence in the process, and then I spent an hour and a half and I read them the results. I repeated it as many times as they wanted me to, so that they had sufficient information to understand why we considered their proposal to be flawed and what they needed to do in order to make it a more successful proposal if they wanted to come back.

That turned out to be magical. The reason why I was told not to tell them anything was we would get protests, and the whole process would be stopped. I went, "If we screwed up the process should be stopped. So if I tell them the truth and we screwed up, yes, do something." We got no protests. I got a wild set of responses from the people that I debriefed, crying, shouting, screaming, accusing me of cooking the books and all those things. But I knew that we had done a good job and we'd done absolutely the best we could to try to be fair. I felt confident that being honest and open with them would help them and help us in the end, and it did. That process went on for quite a while. As a matter of fact the National Academy of Science did a study of PI-led missions, I don't know, four, five years later. I can't remember exactly when. I do have the data but I don't remember exactly when it was. One of the things that was important was that we shared with the proposers what their flaws were so they could correct them and make improvements to their proposals. It is typical that a proposal that wins in one of these solicited missions like this goes through more than once as they clean up and fill in the things that were flaws.

I want to go back to the numerical scoring. After the first round it was really obvious to me that the numerical scoring was a bad idea. Once I really learned how the science community felt about the science, how they graded the science, very good being not very good, I went, "Okay, we need to be a little different." Our criteria for measuring became more subjective. We shifted over to a process where we asked for less information in step one, more information in step two. Step one is a formal procurement process. Step two is treated like a formal procurement process but it's not. You don't have to follow the procurement rules in step two. But we typically do anyway just so everything's as clean as it can be.

But the grading became a little bit more subjective, so that the things that Jim Martin had pointed out actually could be used as the basic criteria for why this particular proposal had a major flaw, whatever the case might be.

Over the years this has waxed and waned on what we ask for. In my opinion today what is asked for in step one is now the same as what we asked for in the original AO. What they ask for in step two is really a lot of Phase B work, a lot of the preliminary design work. We've over time gradually added back more and more requirements for information from the proposers. It costs a lot of money. It's in the millions to put together a step one proposal now. Step two proposal is in the multiple millions, it's a good $5 million to put together a concept study report.

If you think about it, we're dropping $10 million to $15 million, maybe more on just picking a mission. Forgive me for jumping around, Sandra. One of the real criticisms of the Discovery Program today, has been all along, is that the Discovery Program and its companion programs—I'll come back to that in a second—are too risk-averse. If you need new technology to implement your mission, whether it's an instrument or a technical capability on the spacecraft, whatever the case might be, you don't have any chance of getting picked. There's some

legitimacy to that criticism and concern. My response to that, which I think goes back to one of your questions at the end, which is lessons learned, is that before one changes the way you approach these PI-led missions, you need to think about the overall whole Office of Space Science portfolio risk. The way NASA and the Office of Space Science—this is my personal opinion—approach this is that they use the PI-led missions and these smaller missions as the justification to our outside stakeholders that we know what we're doing, that we can generally deliver these missions on time and on budget.

There's been a bit of a sordid history over the 30 years that we've done this. But we're in a period where we do a pretty good job of evaluating the proposals, picking them, and then managing them as they go forward. Where NASA places its risk, the Office of Space Science places its risks on its bigger missions, Mars 2020, on Europa Clipper, on Cassini. Those missions are really pushing the technology because they're big, they're doing a lot, they're complicated, and so those missions have a tendency to get into trouble. NASA says, "We're doing big and glorious things on these missions. We're sorry that we were too optimistic." I could spend a whole day talking to you about this topic. But before people change a PI-led mission concept, how we approach this, they need to think about the overall risk posture for all of the Office of Space Science, so that if you add more risk to the PI-led missions you understand what you're doing and how it affects the overall portfolio with our stakeholders. That's just my personal opinion.

JOHNSON: You mentioned they were risk averse. Is that more for the launch vehicle? Reading that document we had talked about, one of the goals and objectives was to encourage the use of

new technologies. Encouraging that creates risk right there. Where are they being risk-averse? Is it all over or is it just the launch?

SAUNDERS: That's a very good question, Sandra. This is the way it worked. This evolved. That's what we wrote, and what we wanted. But when we sat down to review them, to sit down with the proposals to review them, those people who were proposing new technology—so there were proposals. As an example, before NEAR landed on Eros, nobody would believe that you could land a spacecraft on an asteroid. Proposals to land and sample asteroids were being killed by the evaluation process because the competitors all were proposing things that were common technology. The proposers learned don't do that.

Then we started asking for them to [do that]. If you're going to propose a new technology, show me why I should have confidence that you can actually deliver it. If something happens, what are you going to do about it and provide backup?" We started asking for that. The proposers that did that fared better than the proposers who said, "Trust me, I can make this work." This is just an aside.

I will say that I've read hundreds and hundreds of mission proposals. The number of proposers that don't answer the questions asked for was probably 90 percent. You just read it and go, "I don't get it." I spend time now helping proposers. I lead some teams that review the preparation of the proposal and I go, "You didn't answer this question. You didn't answer that question. If you want to get picked you have to answer these questions."

One more funny story on Discovery, and then I want to talk about the evolution of Discovery. You asked me about Stardust and you asked me about my involvement with Stardust

and Lunar Prospector. On Lunar Prospector Scott Hubbard really did the hard lifting on that. I turned it all over to him. He was great at it. I didn't have to worry about it much.

On Stardust we were getting ready for the preliminary design review, and as you know in NASA the preliminary design review is a big deal. This is where we make our commitments to our external stakeholders on what it's going to cost. Ken [Kenneth L.] Atkins, who was the Project Manager—I think it was about one month, might have been two before PDR—calls me up and says to me, "I need some advice. The current design won't get off the pad. It's too heavy. Do you want me to hold the PDR?"

My response to him almost word for word was, "Ken, if you want to be canceled, hold the PDR. If you don't want to be canceled go fix the problem and then we'll hold the PDR. Don't come back to me with a problem. You fix the problem and then hold the PDR." Which is what we did. That was not very common in NASA either. I'm going, "No. Get your act together, get the design correct." He needed to make a change to the launch vehicle. That was the problem. To get a little bit more capability on the launch vehicle by adding some more solids. They went and solved the problem and we held it like three months later. They passed the PDR, went on, totally successful. That really worked out.

That's another in my view lesson. Don't hold these reviews. You asked me about IPAO [Independent Program Assessment Office]. We can talk about that if we have time later. But my feeling is if you're not ready to hold the review, we have a certain set of expectations for the maturity of your design, if it's not that, don't hold the review, just put it off. We'll deal with the problem later. That was a funny story.

As you know, the Explorer Program was already in process. The Explorer Program at the time was being managed with a more traditional prior to Discovery approach, not a PI-led full

mission proposal process. After the success of the first AO of Discovery, the Office of Space Science really began to think about moving Explorer Program into a similar model. Then the Earth science program also began to think about that. I helped both of those groups while I was still doing Discovery and the Space Science Support Office implement those processes so that all the smaller missions in the Office of Space Science were PI-procured, generally PI-procured. It was very good for the community, really got a lot of people involved. It's been very successful in my opinion.

My personal feeling is that this approach has been very successful. If you think about the recent Astrophysics Decadal [Survey], that was part of the Decadal, but I think they recommended that they add another class of a bigger mission more like New Frontiers. Discovery is just generally $500 million now. New Frontiers is $1 billion. I think astrophysics has now added a bigger mission class to fill in that gap between James Webb, which is $10 billion, and a MIDEX [Medium-Class Explorer] proposal, which is $250 million. The evolution of Discovery has been, I think, very helpful to both the scientific community and to NASA in getting more missions. As the technologies evolve, we're getting more and more science out of the smaller missions. When we first evaluated outer solar system missions there were missions that were proposed to go to Jupiter with solar power and we just trashed them in the very beginning, going, "There's no solar arrays that have enough power at Jupiter." But that's not true anymore, because Juno is now flying around Jupiter just fine, and Europa Clipper is going to go in two years and it's solar powered. Now we're pushing the solar power out beyond Jupiter. As the technologies emerge more and more gets done with less money. That's been significant too.

I think the community is generally happy. They whine, everybody whines. But I think they would be more unhappy if we went back to the old way of doing business. Let me think if there's anything in particular. Let me talk about one other thing that I think has been important. Paul [L.] Hertz, who recently stepped down as the head of astrophysics, took over the job in NASA of managing the AO process for a while. This was 10 years ago, maybe even longer than that. Paul was in my personal opinion very thoughtful about making sure that these programs were in fact meeting the objectives of the scientific community and held a number of workshops to let the community bring in their opinions and make adjustments to the process. All of this has gradually evolved over the last 30 years. It's gotten better and better in most respects.

I think the one area where I would want to poke the Office of Space Science is in the feedback. Back to the point where I told you I sat down and told them everything. They give them the written feedback now. I didn't give them the written feedback because I was directed not to. But what happened between the two—this is a lessons learned. What happened is by not giving them the actual written feedback, we could have a conversation about the flaw, so that I could explain it, rather than allowing the words that were on the paper to stand alone. The words on the paper, if not written exactly precisely, can create confusion or permit the wrong conclusion. The conversation in my personal opinion was very very important, so that the proposer understood what the flaw was and not worry about what was written on the paper. My understanding from talking to many people who are on the receiving end of the feedback is they've neutered the language in the feedback so much that they don't understand the flaw anymore. I think that's a shame. It's not serving anybody well. It's more risk. There's less risk in the way they're doing it, but there's also less reward in the sense that the proposers are not getting the best feedback that they can.

Other than that, they've done a lot of things in the Office of Space Science to really make these programs good. I'm very happy about them and feel that I was at least a small part of it. All right, so I've talked for over an hour. My wife tells me, "Don't let them push the start button because you'll never shut up."

JOHNSON: No, as an oral historian I appreciate that. I do have a couple things I'd like to go back to. You've talked about it, that PI-led program concept. You talked about how different the culture was, and then also having engineers and scientists in the same room, and their reactions being so different. But part of the whole concept of these Discovery missions is it's PI-led, which is by the science team, but they also have to work with project managers, which you've been that position for a specific mission, but also engineers that help them create what they're trying to do. Talk about those relationships and if those roles have changed since the beginning. Or do you see that they're different now since you're helping on these proposals? Just the evolution of how those roles—and I know early on at the San Juan Capistrano, I think the second one, the workshop, they were trying to define those roles and how they would work with institutions and commercial partners. But talk about all those roles and those relationships for a few minutes.

SAUNDERS: That's really a good point, Sandra. I'm glad you asked me about that. I'm going to talk first about the relationship between the PI and the project manager. I want to talk about that first, and then I want to talk about engineers versus scientists. I'm trying to think of how to start this conversation. This is a difficult conversation and there's been a lot of stress.

I want to talk about where the Discovery Program is located in its history, after we have a conversation about this. The relationship between the PI and the project manager on a team has bounced back and forth between the PI is responsible for everything to the PI is responsible to the scientific integrity of the mission and the project manager is responsible for the implementation. There's been this conflict back and forth over time, and it's gone like this back and forth.

My personal opinion is it is bad management to ask somebody to do something that they are not capable or competent at accomplishing because you're just asking them to fail. It has always been my personal opinion that you don't put people in a position in which you're asking them to do something they're going to fail at. That just seems like bad management to me.

The principal investigators are scientists. Most of them are not hardware—or maybe I should say many of them are not hardware-competent. They're not the Phil [Philip R.] Christensen. Phil Christensen was one of the two cochairs of the Planetary Decadal that was just released last month. Builds a lot of instruments, building instruments, and he really knows hardware, and he's a PI. He's a guy who knows hardware. But if you go back and you think about Don [Donald E.] Brownlee, who was the PI of Stardust, he had little to no hardware experience, and he relied on Ken Atkins, the JPL guy, who was the hardware guy, built hardware, knew how to build hardware.

It is difficult to say that the PI is responsible for everything when they don't know how to make decisions on engineering details. As I said this has gone back and forth. My own personal concept of this was the PI is responsible for the scientific integrity of the mission. That means that any decision, any decision, that affects the science has to go before the PI for a decision on whether or not you're going to sacrifice some science to solve some problem that needs to be

solved. If it's just an engineering implementation issue then the project manager can handle that. If it's a mission risk decision then both of them need to be involved in that. It's a fine balance between the project manager and the PI and their working relationship. Every one of them is different and every one of them in my personal opinion ought to be different. They ought to match the personalities, the knowledge, and the skill base of each of the two, and they should be matched up. The two need to have a lot of trust in each other so that there's good communication between the two. If that happens then you have a place where good things will happen and good proper decisions will be made.

I'm going to get into the engineer scientist discussion, start it with another story on Stardust. Stardust was flying a material called aerogel. Aerogel, if you've ever seen it, looks like smoke although it has a firm consistency, it's the coolest thing ever. It was developed by a guy at JPL named Peter Tsou if my memory serves me correctly. Peter Tsou was a scientist. He was responsible for the aerogel, and they didn't finish the aerogel until loading it into the paddle. Ken Atkins would call me up whining and moaning about Peter Tsou. "I can't get him to stop." It was hysterical. Wasn't funny, but it was hysterical, nevertheless.

This is just my observation is that scientists want as much as they can get, and they write requirements, so the requirements documents in these, they belong to the scientists. They belong to the PI. Sometimes they are based on desires and less on what it is that's really required. I'm on the standing review board for Europa Clipper and we just beat them about the head and shoulders because they kept asking for more science than was necessary to meet the Level I requirements. It took us two years to get them to fix that problem, to back off, save money, build a less capable set of instruments and spacecraft that you could actually come close to fitting in the cost box.

The science community is always pushing for more and more science, so their requirements sometimes are not necessarily what's necessary to meet the objectives that they set out for themselves. There's this tension between the engineering community and the science community over this. That tension can get destructive. That has to be managed by the head of the system engineering organization, so your project system engineer who's also the technical authority, the project manager, and the PI. Those three have got to get together and make sure that when we communicate, because our styles are different, our thought processes are different, and our needs are a little different, we have to be able to keep that gap closed. That's a constant process. It happens all the time, happens every day, and I've seen it work well, I've seen it work poorly.

I'm not smart enough to fix it. In the proposal process, it's been interesting for me because—I won't share names but over the last 10 years I've been helping an organization with them preparing proposals. The first thing I tried to get them to do was to actually answer all the questions. That was difficult. Some PIs think they're smarter than the people who are asking for the information, and I've reviewed one proposal three times that's never been selected. I never thought it would be selected because the PI would not listen. This is a case where I've just been a graybeard offering advice, you can take it or leave it. But if you don't want to take it, I've shared with you why I'm sharing this, so it's at your peril. I've worked more recently with that organization. They finally got over that part. Now they're listening to and answering all the questions.

But there are some cases in which they put together a technical approach that solves the science problem that creates an engineering problem. In this process these groups of people have begun to listen to each other. That has been quite rewarding because two of the last proposals

that I helped them with—this is not just me, there's 20 of us that are helping them—the PIs are listening, and their teams are listening to the feedback and accepting the concepts. It's gone both ways. The scientists are doing a better job of explaining what they need and why to the engineers, so the engineers are going, "Okay, as I try to develop a solution to this for our proposal, does this work?" The two are working together better. That takes a culture of leadership at the institutions that are involved, both the university and industry, and the NASA Center, because there's usually three, at least three, maybe more, talking to each other. I have been very satisfied. Satisfied is not quite the right word. I feel really good about how they're doing so much better because they both got picked. One got picked to do a Phase A, and the other one got picked to fly. I'm going, "That is very cool. It went through the first time. First time. Wow. Very cool. You guys did good."

That didn't really answer your question, but I explained the difficulties.

JOHNSON: Yes. It does answer that, and other people have talked about that. When they do the site visits, that's one of the things they look at is how well those teams work together, and if they're all answering questions instead of one person and those kind of things. I think that's pretty general for most types of projects. You want the team to work well together. But have you seen teams get picked that maybe weren't successful because of any of those interrelationships within the team?

SAUNDERS: I'm trying to think.

JOHNSON: I was just wondering how much support they get in those relationships. You are outside of it now and you're helping them understand what they have to do and how they have to listen. But in NASA itself, how much support do they get to help with those types of issues?

SAUNDERS: That's an interesting question. I don't think I know the answer to it, Sandra. You've started to poke at something I wanted to talk about. I'm going to use Discovery as the mechanism to talk about this. Discovery is my favorite job I ever had, absolutely my favorite job I ever had. I loved it because I love science and I love working with scientists and I love helping people. I got to do all of those things.

Dan Goldin came into the Agency in '92. I came to Discovery in '94. I want to talk about some changes that happened to Discovery as we talk about Dan Goldin's tenure. Two things about Goldin. One, when I was Program Manager for Discovery he was focused on Mars. When I worked for the Navy's Trident Program [submarine-launched ballistic missile], the [U.S. Air Force] Peacekeeper Program, the MX [intercontinental ballistic] missile, we loved it. We in the Navy loved the Air Force's program because everybody was focused on it and left Trident alone. We were left alone. I thought of this all the time, because when I was working on Discovery, Goldin was focused on Mars. He forced them to do things that were just absolutely idiotic.

I watched it. I sat there, and my colleagues and I watched the decisions he was making about those programs, and I went, "This is not going to turn out well." Discovery was under the radar, and so I could manage the program and put into place the things that were necessary to make the program successful. We haven't talked about managing the program, but maybe we'll

get into this now. That's one thing. I got to run under the radar and just do this on my own, which was so cool.

The other thing was that Goldin's notion of Headquarters was a classic industry-based headquarters model. It was fundamentally strategy and policy for the organization. Technical capabilities were out in the field. Goldin wanted to downsize, and my memory on the numbers might be wrong, but he wanted to downsize Headquarters from 2,000 or a little bit more than 2,000 down to around 700 or 800. I may not remember that exactly right, but the notion is correct. He basically wanted to get rid of the technical capability at NASA Headquarters. For human spaceflight, that was fine. For robotic spaceflight, that was a disaster in my personal opinion, because the decision making for selecting missions stayed at Headquarters with no technical capability to do it. Just stupid.

When Goldin said, "We're moving the program office out," I knew how the program worked. When he said, "We're moving the program out, we're going to move it to JPL," All the decision making is staying at Headquarters, and only administrative and oversight functions are going out to the field. But all the intellectual property is staying here. I went, "I'm not interested in doing that."

I elected not to apply for the program. They put it at the NASA Management Office at JPL. I think Dave [B.] Jarrett was the program manager. I may not remember that right. You're going to talk to him. He'll be able to fill all this in.

I said, "I'm not going to go." At that time a guy named Bill Smith at Langley and a couple other people came up with the idea of moving the solicitation process which was staying at Headquarters out of Headquarters to Langley. That was the start of the Space Science Support Office. I said, "Okay, I'll do that. I'll be happy to go do that. You're neutering NASA

Headquarters anyway." My wife was interested in getting out of DC. This all just really worked.

I went down to Langley and set up that office, hired Wayne Richie and all those people. Wayne, God love Wayne. He's such a nice guy. John Lintott and a whole bunch of others. We started not just doing Discovery, but Explorers and Earth science, all that stuff. That office has changed names but it still exists [Science Office for Mission Assessments]. It still does the job.

But what happened when they split the program office off was they failed to delineate the responsibilities for managing missions and managing the programs between Headquarters and the program office. I've only thrown my badge on the table one time. After [Michael D.] Griffin came in, see if I've got this right—I've jumped. I'm just telling a story.

I became the head of the IPAO in 2005, I'm telling a story about program offices versus Headquarters. I had sat in SSO [Science Support Office] for three years managing Discovery, not officially but managing it, while they set up the NMO [NASA Management Office] and got all that stuff going until Dave took over, and watched this conflict, this misunderstanding, between what the program office was responsible for versus what Headquarters was responsible for. It really troubled me because it created confusion in the missions. Who do I talk to? What role, what responsibility do they have? It still happens today.

After I took over IPAO, I was aware of this, and I recommended to my boss at the time, Scott Pace, that we do a study of this relationship to identify where these problems exist so that people could think about how to solve them. I don't consider this to be a funny story. But I asked Noel Hinners. Noel Hinners was a god, he was head of the Office of Space Science, he was the head of Goddard, he was the head of civil space at Lockheed, he was a god, and the nicest man ever. I asked him to set up a team to go look at this problem. Scott gave me

permission to do this. I asked him to set up a team to go do it. He did this study that said these are where there's lots of confusion and we ought to do something about fixing it.

There was the Program Management Council [PMC] at Headquarters, and we were asked to present our results. Noel Hinners is making the presentation. He did the study. I'm in the room. Noel Hinners starts to give the presentation. He's on the first page. The chair of the PMC angrily stops him and said, "What idiot started this?" Yes. Word for word. Room full of 30, 40 of NASA's top management. I'm over on the side. I raised my hand, said, "I did." Then he proceeded to chew me out. The rest of the presentation, Noel gave the presentation, was pointless. Absolutely pointless. He wasn't listening. The AA was pissed. He wasn't listening. In the next two weeks I got feedback that he was trashing me.

I went into Scott's office one night and I threw my badge on the table and said, "I'm done, I'm out, I'm going home, and you'll have my resignation." I was at Headquarters but I lived in Hampton, Virginia. I drove in. Anyway, make a long story short, I got a $40,000 boat out of it. That was kind of funny.

This issue of the relationship between the program executives or the project executives, the people who sit in the Office of Space Science, and the mission managers in the program offices, the relationship is still somewhat ambiguous, somewhat confusing. The flow of decision making is not as crisp and clear as it should be, creating some conflict for the projects. I'm just going to go to today. I'm being hired by a university. I have a meeting with them tomorrow. To help them with this problem. Who do I talk to? How do I talk to them? I'm going, "Yes. Okay." I'm being hired to help them. I'm going, "Wow."

JOHNSON: That makes me feel a little bit better because in my research just trying to get it straight in my head what the different offices do, I keep thinking I can't get a straight idea or a straight answer about what each one does. I'm glad to know that it's not just me.

SAUNDERS: No no. It's very confusing. I'll just share a story with you. It's off topic a little bit. When I came to NASA, the Trident Program was the best managed program I've ever seen, ever ever ever ever. When I came to NASA and I was working on Space Station, I spent an enormous amount of time wondering how NASA ever got anything off the ground. My perceptions. I told you that the cultures were different. That certainly proved to be true. But when I left working for the Trident Program I said, "I don't think I'll ever run into people who are smarter than the people I just worked with." I got to NASA and I went, "Oh, okay. Now I've run into people who are not just smarter but way smarter." The people at NASA are just beyond brilliant. But my personal opinion is NASA couldn't manage its way out of a wet paper bag with a bulldozer. I've spent years and years. When I was on Space Station, I just used to shake my head all the time about—I did a paper. I still have the paper that showed how the relationship between all the pieces worked, and it looked like spaghetti. The Program Manager for Space Station had no authority for the money. You go, "This is insane, just insane."

Ever since then I've wanted to help the Agency see how they can make it better. Thomas [H.] Zurbuchen, who was the head of the Office of Space Science, asked Orlando Figueroa—Orlando wasn't related to Discovery but he's a great guy, he ran Explorers for years—to do a governance look. How are we managing flagship missions? Why do we overrun them? He and I led this group of super people, top-of-the-line people from around the country, about a dozen. Root cause analysis of why NASA overruns everything and we can't get our act together. He led

the root cause analysis part of it and I led something called causal loop diagrams. I don't know if you're familiar with them. Wouldn't hurt to look it up—but it draws relationships between things and actions, so you understand how one influences the other. They're part of a system engineering process. I connected each of the root causes in the Agency through the whole process, all the way from Congress and the administration down through to the actual project and showed how the root causes were affecting what they were doing.

There are some fundamental basic problems in NASA that it won't acknowledge, period. It just won't acknowledge it. If you think about this relationship between the program office and Headquarters, that's just one of those pieces of where the misunderstanding between what you're asking people to do and their roles and responsibilities is creating situations in which we just overrun and you won't know why. Anyway, I'm sorry, I digressed.

JOHNSON: It's all good information. They've moved it to Marshall [Space Flight Center, Huntsville, Alabama]. It was 2014 I think, the program office is now at Marshall.

SAUNDERS: Correct. New Frontiers and Discovery are in the same Program Office. Goddard still manages Explorers and Langley manages the Earth System Science Pathfinder. Those are the fundamental three PI-led program offices. Marshall is trying, they're trying hard, and they have highly competent people there.

JOHNSON: We've been going about an hour and 40 minutes or so. Do you want to keep going talking about some other things? Or do you want to break and set up another time to talk? We can go back over some of the things we've already talked about and flesh those out. Or we can

go on and talk about what you did when you went to Langley, because that was still related to Discovery, and of course what you're doing now is still related. It's up to you.

SAUNDERS: This is actually energizing for me. I'm fine. I don't know how you are, but I'm fine. I'm happy to do either. As I said, this program is my favorite thing I ever worked on.

JOHNSON: That's good. We talked about some of these, so I'm just going to go back over some of these questions I had. Talk about how the AOs have changed or if they changed. I know in crafting that first one things have somewhat changed and maybe hopefully as you said that you were trying to simplify it so that they didn't have to add so much. But things are going back that direction again. There's more online that they can use to answer some of those questions as far as to be successful. Is there anything else about that that we haven't talked about that you wanted to bring up about the AOs? I think it's interesting the idea of it, that you release this and then people come up with these ideas, and then they have to convince NASA that it can be done. But is there anything else we haven't talked about about those AOs that you'd like to?

SAUNDERS: I mentioned Paul. One of the things that I think they've done a really good job—I'm jumping around in my head. I mentioned this before. I don't talk about this. There have been in my opinion three big changes in this process. The first one was the one I talked about between the first AO and the second AO where we went from a one-step process and a quantitative evaluation to a two-step process and a more subjective evaluation. That was one. Two was when the Mars failures occurred. We haven't talked about this but we should talk about that. What impact did that have on Discovery? I'm prepared to talk about that. Then the

third one is what I would call as Paul Hertz and his continually tweaking the process to make it more suitable for the community. Those have been the three big things. We talked about the first one.

The second one. My memory may be slightly flawed but it's not off by much. Stardust was $216 million if my memory serves me correctly. Genesis was a little bit more than that. After the Mars failures, the way I approached overseeing the program was my philosophy was trust but verify. The simple way to think about it, trust but verify. I put together annual teams. It was part of the NASA process at the time. But teams to actually go in and assess how the projects were doing so that we could keep an eye on them and be sure that they were doing things that they needed to be doing and achieving their objectives. They were left alone in the institutions to some degree as well. The cost was in the couple hundred million dollars.

After the Mars failures, and after the review board found the flaws in what happened to both of the spacecraft that we lost at Mars, everything changed. Enormous amount of process went back into the system. We probably—this is just a guesstimate—doubled the cost of a mission by just putting on more and more oversight on top of the missions. That's unfortunate, because we do half of what we could do, because you still have to spend the money. It's money to oversee and it's money of the overseeing to be overseen, because it just takes time as you know to get prepared for it. Multiple groups. I lament about that actually. I'm a big fan of independent review. But I'm not a big fan of independent review for independent review's sake. I'm a big fan of I'm not smart enough to see everything that I do, and it sure is nice to have somebody come and sit in my office and tell me I'm about to screw up the program.

But I think Paul really focused on trying to do things that would help the community. The Program Library, we tried to set one up in the very beginning. But it's evolved and it's

gotten better and better. There's a lot of material on the Program Library. There is a standard AO out there that people can use even before AOs come out. I think that's what you heard. There are these things that you can go get the criteria and the guidelines for what to put in proposals and concept studies are out there. All of those things are designed to help the community, and the community uses them, then they do better. I think that that's all been really good. I'm happy.

I do think, as I mentioned earlier, that we've gone too far on asking for too much information. I think you could back away from some of that, lower the cost of these proposals and concept studies a little bit. But in my observation at Headquarters over time, they don't want to change the process because it's successful. If I'm getting free money out of industry and universities, why do I want to stop that? I've heard that kind of language before, and it's really difficult to argue that. They're getting work for nothing. I'm going, "Okay."

There's also the issue of technology and whether or not we've become too risk averse. If I were king, I would probably implement an overall risk management study of SMD [Science Mission Directorate] as a whole, how is my risk posture across everything I do, and am I satisfied with the way it is or do I want to make some adjustments to it. That's what I would do. But I don't think they're doing that.

I want to talk about one more thing because this was really important to me. It was important to the program at the time. I told you that Al Diaz came to me in the very beginning and said, "You better pick a small mission. If you don't pick a small mission, bad things are going to happen to you."

That worked out okay. But the program scientist at the time that I was the program manager and for some time after I left was a guy named Jay [T.] Bergstralh. Jay is not with us

anymore. But I love Jay. He was a great guy. He and I developed a relationship in which he managed the peer reviews of the science and I managed the technical, management, and cost reviews of the implementation. We worked together to find a way in which to allow missions that were not at the cap to compete with missions that were at the cap, so that Stardust, which was $216 million all up, was below the cap, competing with missions that were—you've probably heard the Christmas tree term. Basically missions that are Christmas trees. I put as much on here as I possibly can get and that way my science will be more. I'm doing more science.

Over time the program has evolved to Christmas trees. Missions that are proposed at less than the cost cap that are not flying as many instruments and doing as much science as they can, won't compete against a mission that's flying as much as they can possibly get on it. I think that that is unfortunate. It's not a windmill I've been willing to attack. Just take it as whining. When Jay and I stopped working together it gradually shifted over to Christmas trees.

I will share one more thing with you because we haven't talked about cost analysis. Cost analysis in NASA has a sordid history as I'm sure you're aware. Cost analysis is an art form. There's no question in my mind about that. The cost assessments of all these proposals was a big part of our job. I used very very competent cost analysts out of Aerospace, out of SAIC, out of other organizations to do the analysis. They typically did statistical analysis on the cost around standard deviation.

When I was the head of SSO the head of the SMD was Ed [Edward J.] Weiler. Ed did not trust the cost analysis, and so we would do statistical analysis and he would pick missions that were one sigma low. That's not the right way to think about it, and so a lot of missions during that period were overrunning because you only had like a 20 percent probability of hitting

that number. He was thinking about it one way rather than thinking about it in terms of what is the probability they can actually do this.

One of the things that Griffin did was to establish the JCL, [Joint Cost and Schedule Confidence Level], and pegged it at 70 percent. That was a very very bright idea and it helped the Agency actually really get control over the cost. You had a 70 percent chance of hitting the number as opposed to a 20 percent chance of hitting the number. Ed eventually learned. He didn't trust the number. We tried to explain it to him. But cost analysis is a bit of an art form. It's had ups and downs over time. Sometimes we do good, sometimes we don't do good about it. It applied to my role in IPAO as well.

I talked a little bit about this, but the Agency is incentivized by everybody, inside, outside, to be optimistic.

JOHNSON: One of the things I wanted to talk to you about was outreach and education. Again going back to those first goals, that was part of it. I want to get your thoughts on the importance of outreach and education for Discovery, and just public awareness of what Discovery does.

SAUNDERS: That's a fabulous question and one fraught with lots of trauma and emotion. I'm a huge fan of public outreach. I'm a huge fan of education. I think NASA does an abysmal job of promoting itself. Happens to me every day when I speak to friends and colleagues around the country, as I'm sure it is for you as well. Everybody, we all suffer from the same thing. I never heard about that. I said, "Well, the information is generally out there, but it's usually targeted at a very informed and specific audience. The general public doesn't ever hear much about it except when something really bad happens."

I always thought that the notion behind public outreach and education was a great one, and I thought requiring all the missions to do them was a great thing to do, and I'm going to come back to this in just a second, and if I don't, remind me. It was very dissatisfying actually that NASA was directed to stop all that. Education and public outreach has been a big giant football in the Agency now for probably 10 years and it's just really horrible, awful. Everybody is suffering from it.

I will share with you just as an aside. For six years leading up to this past fall I was a member of the Committee for Astrobiology and Planetary Science [CAPS] at the National Academy of Sciences. We talked about this all the time. Why aren't the missions doing education and public outreach? We watched that ball get moved all over the place. We would have PIs of missions come in and talk to us and whine about we don't get the money, we're not allowed to do it, we try to engage, and it's just very very unfortunate. It's become a political football. It's unfortunate. It comes up. I'm now a member of the Space Studies Board, which is the parent of the CAPS, and we talk about it there too, just wishing that NASA were more allowed to allow the money to be spent by the projects who have the information at their fingertips and can work with all the educators and the public.

Some of the institutions are doing okay, the bigger missions get some publicity. There's some clever things, but anyway.

JOHNSON: Some of the parts of the missions have collaboration with some schools or universities, as far as getting other things on there, I guess decking out that Christmas tree with all those different things from students also. Maybe that helps get the word out a little better.

SAUNDERS: I agree that that was a step in the right direction. People are trying to find clever ways to work around the political football.

JOHNSON: One thing I've noticed just from working for NASA for so many years. The big things like Mars, that's something, and like you said, Dan Goldin, that was his thing. Mars has always been something that people are fascinated with. You'll see reports on that and you'll see that information in the media. But the other missions not so much.

SAUNDERS: Right.

JOHNSON: That's unfortunate, I think. There's so much that Discovery has done, and even working at NASA I don't hear about it. That's sad that we don't even educate the people within NASA unless you're working on that project or directly related to it. It's unfortunate to me.

SAUNDERS: It's interesting. I'll just share with you. As a member of the Space Studies Board, Thomas Zurbuchen, and his senior leaders of the four or five groups under him comes to the Space Studies Board and make presentations on all the work that's going on. You go, "God, NASA should be doing town halls where this information is presented to everybody." It's fascinating. They're all generating this one chart that shows all the missions that are flying right at the moment. You just go, "Oh my goodness. Wow."

JOHNSON: I would love to have that chart because it would make more sense to me, because I like charts. Timelines and charts. Yes, that would be great if they did that kind of thing and

produced that and made it available for people. I think it would generate some of that excitement. Because everyone that works at NASA can be a promoter.

SAUNDERS: Absolutely.

JOHNSON: I think I'm going to stop for today just so we can look at everything. I know I have more, and you may have more in your notes to talk about.

SAUNDERS: That'd be fine.

JOHNSON: Okay. Thank you for joining me today.

SAUNDERS: Oh, Sandra, it was fun. You pushed the start button.

[End of interview]