NASA HEADQUARTERS ORAL HISTORY PROJECT
ORAL HISTORY TRANSCRIPT

CHARLES BOLDEN
INTERVIEWED BY REBECCA WRIGHT
WASHINGTON, DC – JUNE 5, 2017

WRIGHT: Today is June 5, 2017. This oral history session is being conducted with Charlie Bolden in Washington, DC, for the NASA Headquarters Oral History Project. Interviewer is Rebecca Wright, assisted by Sandra Johnson, and we both thank you once again for coming in and talking with us today.

BOLDEN: Thank you.

WRIGHT: From July 2009 to January 2017, you served as NASA's 12th Administrator. You started your tenure with a new President [Barack H. Obama] who placed you in charge of a redesigned and reinvigorated program that focused on leveraging advanced technology, international partnerships, and commercial capabilities to set the stage for a revitalized human spaceflight program for the 21st century. Also, you became responsible for accelerating the work on climate science, green aviation, science education, and other agency priorities. That was your charge.

BOLDEN: It was. I'm not sure I knew all of that. It's kind of hard to get all of that out of my one, 20-minute conversation with the President before getting the word months later that he was going to nominate me to be the NASA Administrator. During that visit, I was really listening to him as much as anything else. He had a number of questions, but he did not mention "NASA

Administrator." That was not the subject of the conversation. He wanted to, I guess, pick my brain on where I thought the space program was, where we could be going, and he wanted to make it very clear that he really was a believer in technology and technology development; that he thought we should be back into deep space. He said, "The Moon will be important, but we have got to go beyond that, and we have got to go to stay."

And then he told me the story about how he had been inspired when he was a kid. growing up in Hawaii. His grandfather used to take him down to the pier to see the carriers come in with the Apollo astronauts and their capsules [Command/Service Modules]. He said he remembers what he felt like back then, and he wanted American kids to be able to do and see the same kind of thing. So he got me started using the word "inspire." Later, I learned sometimes to kids from minority communities "inspire" is a very good word to use. A young man who at the time was with the student chapter of the National Society of Black Engineers told me it's kind of hard to inspire somebody if they are not first informed. So, I learned that you have to let them know what's out there, and then you can inspire them.

But that was the subject of the conversation with the President. In that short period of time we talked a very little bit about the value of a [National] Space Council. I told him I was vehemently opposed to it, and I told him why. Whoever his Administrator was going to be, it would put an unnecessary layer between the President—who is the boss for the Administrator as an independent sub-cabinet organization—and the NASA Administrator. We talked about the need to go ahead and phase [Space] Shuttle out, so that wasn't a surprise to me.

What was a surprise—what was a shock, actually, when the budget came out—was termination of Constellation. And we didn't really talk about Constellation, because my

assumption, since he believed in deep space, was that he was going to allow it to go on. So that one came as a shock when we got our budget numbers. Yes.

WRIGHT: Let's pick it up from there, because about the time you were confirmed, you began dealing with the decision of the cancellation to "go to the Moon and then beyond." Plus, it was being replaced with, as some considered, a radical change to use commercial industry for space transportation. So tell us about those first days, and how you managed to move through it all, because there was quite a bit of controversy, internal—

BOLDEN: A lot.

WRIGHT: —and external.

BOLDEN: I was going to say internal and external, and within the administration, because like I said, the part about terminating Constellation had caught me by surprise. I wasn't opposed to phasing out of Constellation, but I thought we should reshape it. Because I knew from my time on the Aerospace Safety Advisory Panel—the ASAP—that Constellation was just in bad trouble: schedule-wise, funding-wise, and everything. And it had gradually degraded from a Moon, Mars, and beyond program to a Moon program. But it was a Moon program with no way to get a lander, no way to get anything due to cost overruns. All we were doing was working on two vehicles—well, three when you count Ares I, Ares V, and then Orion [Multi-Purpose Crew Vehicle—but we had no transfer vehicle; we had no anything.

Had I known that I was going to become the NASA Administrator, what I would have recommended to the President was to, "let's take a look at where we are, and then transition the program from its current state to a better place." And believe it or not, I think we actually are there now, because the first budget that I got was one that said, "Okay, NASA is out of human spaceflight." No matter how it was written, that's what it said: "NASA is no longer going to be involved in human spaceflight; phase out the Shuttle by 2010; terminate the Constellation program; and start building a big rocket engine." We were supposed to build a LOX/RP engine—liquid oxygen oxidizer and kerosene rocket fuel—to replace the Russian RD-180, which was then and it still is the only heavy-lift engine we have right now in the inventory. So that was what NASA's job was to be, and that just didn't sit right.

Before we announced the budget, I had a chance to go over to the White House and talk to Dr. John Holdren [Director of the White House Office of Science and Technology Policy [OSTP]], to the head of OMB [Office of Management and Budget] at the time, and I got no sympathy. They said, "Just press; just go do it." That made it really hard for the budget hearings that year, because I had to talk about something that I didn't fully believe in.

I thought Commercial Crew and Commercial Cargo would be important someday; I didn't buy the fact that it was going to replace everything, and it's going to do it in a matter of years. I was not what I called a "commercial ideologue." What we were up against was a lot of people who came from the Obama transition team that were the commercial ideologues. People had filled their head with the idea: "Just give the money to the commercial guys, give it to SpaceX and others, and they'll run with it, and we'll be flying humans in two years on commercial crew vehicles."

I knew that wasn't true, because I knew how difficult it had been for us to get to the first flight of the Shuttle. When I got to Houston at JSC [Johnson Space Center] in 1980, the Shuttle

was already two years behind. We were supposed to have flown in ’78. When we brought the first group of astronauts in, we were still struggling to get flying.

So what we had to do was try to figure out ways to support the President’s program in principle but try to help folks on both ends of Pennsylvania Avenue understand an alternative way to do that. That’s what we set out to do. I had an incredible team. [William H.] Bill Gerstenmaier, first of all, who just—I mean, his brain functions way faster than anybody else I know. And so Bill already had a pretty good idea, and he and I talked a lot. Also, [Christopher J.] Chris Scolese was the Associate Administrator at the time.

We didn’t get any help from the Deputy [Administrator], because the Deputy was one of the commercial ideologues. In fact, in a way, we actually found that that was part of the competition. So it made it a little difficult, and it made it really hard on the people here in the building because of the fact that as much as we tried to make it look like everything was okay, everybody could tell by body language and everything else that it was not okay.

We went through that for the first couple of years. That’s why I tell everybody my first two years were miserable. They were. They sucked, to put it mildly. And I felt bad, because I felt I was being ineffective. I couldn’t get traction, and I couldn’t get us to do the things that I thought we should be doing, because there was a group of people over in the Executive Office of the President who, in spite of what the President had said, had their own ideas about how things were going to work. So they worked against my understanding of what the President wanted us to do.

It was 2010 when we finally got through a lot of the machinations, if you will, about what NASA was going to do. We had gotten away from that very first [President’s] budget, and we were working on what was going to be NASA’s first real budget out of the Congressional markups.

We started working with members of the Congress. Our champions in the Senate on the authorization side were Kay Bailey Hutchinson [Texas] and Bill Nelson [Florida]. On the appropriations side, you had Senator [Richard] Shelby [Alabama] and Senator [Barbara] Mikulski [Maryland]. It didn't make any difference which party was in power: one of those four people was going to be the leader, and the other one was going to be the deputy, and they all believed in the same thing.

Then in the House [of Representatives], the Appropriations Committee Chair was Frank Wolf from Virginia, and the good thing about him was he didn't have a dog in the fight. He just wanted to be a good Appropriations Committee Chair; he wanted to get NASA funded. So he listened and did the best he could. His only problem—his one major drawback—was he is a strident human rights advocate. He couched everything in terms of human rights, and so that became problematic when we tried to work to bring China to the partnership.

You may remember it was my first full year, 2010. At the end of that first full year, I went to China at the direction of the President, because he and President Hu [Jintao] from China had signed an agreement to start a new China/U.S. dialogue. Part of that dialogue was going to be the U.S./China space dialogue. Bill Gerstenmaier [Associate Administrator for Space Operations], Peggy Whitson [Chief of the Astronaut Office], and I went along with the folks from the International Relations office here over to Beijing, Shanghai, and then way out in the Gobi Desert to their launch site. Incredible visit. We were there for a little more than a week and in Beijing and Shanghai. We had complete access to everything in the Chinese space program, at least in the non-military stuff, although everything's military for them.

We saw *Shenzhou*, which is their new human capsule. It had already flown twice, and they were getting ready for the third flight. We got to meet their newest astronauts, or "taikonauts" as

they call them. There were two women in that group, and they were awestruck by having the opportunity to meet Peggy. Because they knew who Peggy Whitson was—she was a legend. To have an opportunity to meet her, it was just incredible for them.

Then we went into mission control and got an opportunity to go down on the floor, because their [robotic] lunar mission was in progress. They were getting ready to land on the Moon. I was fully expecting that they would say, "No way," when I asked if I could go down on the floor and talk to some of the flight controllers. They looked around and they said, "Sure." So we went down and talked to them; they all understood English. They told us it was *Chang'e*, and they had a rover called Jade Rabbit that was going to come out. They explained the mission to us and told us everything. It just so happened that our Planetary Science people here—Jim Green [NASA Director of Planetary Science] and the others—had provided some landing site data for them so they could pick a place they wanted to land, and then we provided as much support as we could to them. We were sort of working hand-in-glove.

We went to Shanghai, and we saw where they were producing the Long March rocket, as well as starting to develop something that was called *Tiangong*. It's their module for a space station; we got an inside look at where they wanted to go over the next 25 years. Going out to the launch site in the Gobi Desert was like going to the Kennedy Space Center in the old days. They had almost modeled Launch Complex 39 with the launchpad, and the tower where the crew went up and everything. The only thing is, instead of having an escape basket like we had for Shuttle, they had gone back to something that I think we had in the Apollo era, which was a slide—an escape chute that went down underground into a holding or a safe room.

We got a chance to see all that and then came back to the U.S. And when we did, that was when Congressman Wolf said, "Okay, asked you not to go; you did; we are going to put a provision

– the Wolf Amendment – in your appropriations bill that says you can't do any bilateral activities with China." And he did. So that kind of put China on hold for a long time. In fact, we are talking to them again now because he softened the language in subsequent years.

I think had he not done that, given what President Obama wanted to do, we probably would have been well down the road to bringing China into the International Space Station team. We probably would have flown something by now like Apollo-Soyuz [Test Project]. Our proposal was to fly a *Shenzhou* capsule to the International Space Station, have it dock, have their crews come aboard, make sure all that worked, and then let them go back. Then we would figure out how we wanted to integrate them into the ISS program, but we didn't get there. But I think it'll come, yes. Yes.

WRIGHT: What a vision and to have been able to have that happen. I know you have talked many times before about if we go to Mars, it's certainly going to be a multi—

BOLDEN: Oh, multi nations.

WRIGHT: —national event. Well, you managed to get through those first two years. During that time, the commercial sector had come up, moving its way towards resupply [for the International Space Station, ISS]. During this time, one of the adamant decisions you had made, and continually repeated to the congressional leaders who kept asking you the question, was that you were not going to have only one [commercial] supplier. Tell us why you made that decision, and how it's proven out.

BOLDEN: We could not get support for Commercial Crew out of the Congress initially. I think a large portion of their reasoning was the only candidates at the time; we had three. Actually, we only had two, because we had SpaceX and we had Sierra Nevada. Both were okay, but neither making great progress. Brewster Shaw was with Boeing, and Brewster was their person for human spaceflight. Brewster just kept pressing the Boeing leadership as well as their board of directors to get into the human spaceflight game again, and to bid on Commercial Crew.

So as we were getting ready to have to decide from the Space Act Agreements that we use, we were getting a lot of pressure from Congress, particularly Chairman [Lamar] Smith of the House Authorization Committee. Didn't get a lot of pressure from the Senate, but particularly in the House, we were hearing, "Just go ahead and select one, because then you can put all the money on one." But our point was—we *have* to have competition. If we don't have competition, we won't be able to control the cost, we won't be able to control the quality, and we won't get the kind of product we wanted. We battled with the Congress right up until the time that we started building the first vehicles, to be quite honest.

One of the lifesavers, though, was the fact that Boeing made a very late decision to get into the bidding for Commercial Crew. Then, we had Boeing, SpaceX, and Sierra Nevada as candidates—and Boeing, because of their background and the fact that they had been doing work on shuttle all along, they had a pretty strong package. So we selected SpaceX and Boeing as the two providers. Even then, although Congress was a little bit more receptive toward Boeing, they still wanted us to down-select to one. We kept insisting, "You may not like the answer, so just let the process play out." They finally did; we won there.

And just as we demonstrated with Commercial Cargo—having two providers really paid benefits for us, in a number of different ways, not just holding the cost down, but the most

important thing was when we had our first set of accidents. And we knew it was coming. You always are going to have an accident, unfortunately. We lost Orbital [Sciences Corporation Antares rocket]; we lost a [Russian] Progress [spacecraft]; and we lost SpaceX's Dragon, and we went, "Holy geez—what are we going to do?" But we had more than one provider and Orbital came to the rescue quicker than anybody else, because they went out and got another launch provider, and that was the Atlas V. It also gave them an opportunity to go to the Europeans and ask for a bigger module. So while they were delayed several months, when they finally flew, they had a monster payload to go up to Station, and it more than made up for the shortfalls that we had had and the months that ensued after that rash of accidents. And then gradually, SpaceX came back, and then the Russians came back with Progress. But it took an accident to demonstrate why you need to have redundancy in your launch providers.

The other thing it helped us to demonstrate was what we meant when we said we were buying a service. If we had bought a vehicle, if we had specified that we want this vehicle, we'd have been stuck, because then Orbital wouldn't have been able to go out and say, "Look, we can fly on anything. We are going to get another launch vehicle." It was up to them. We didn't care—and we told them that. We said, "We don't care what you launch on, just so you get my cargo to the International Space Station." And so that aspect of the Commercial Crew program also proved out.

WRIGHT: Yes. There was controversy moving into [commercial] crew, mostly because many people within the internal organization didn't want to release that responsibility of transporting humans to a profit-making company. One thing about cargo: you can replace cargo. Can you talk about some of the debate—

BOLDEN: Yes, we can.

WRIGHT: —and the discussion that you had on the inside before that decision?

BOLDEN: The big debate was about what type of control, if you will, does NASA exert over the providers. We used two terms. One is "insight," which says, okay, you are going to get inside their organization, and you are going to depend on them to teach you and tell you what they are doing. But I didn't even realize the depth of insight, what it really meant. We were inside each organization; we had people on their teams. We called them PIT teams, Project Integration Teams, but it meant that we had NASA personnel—we had flight crew, flight controllers—we had everybody that was inside the facilities watching what was going on, asking questions, and everything.

The other way we could do it would have been to have "oversight," which dictates everything they do. They are told, "I not only want this vehicle to be able to carry cargo to space, I want it to carry cargo, and I want it to be green. I want it round," or whatever. That's the traditional way that government contracts are written, where the government controls everything and tells the company how to do it. The company is actually doing the work, but we dictate how that work gets done.

So we went with the "insight" under the Space Act Agreements, and there was a lot of wrangling about that. Some people, particularly on the Human Spaceflight side, as you said—particularly in Engineering and in the Medical Ops side—said, "Unless we can get in there and make very stringent requirements that we can then go back and measure, we can't guarantee that

we are going to get a good product." And so therein arose my very first battle with what we call the "Technical Authorities." This system in the case of human spaceflight is Chief Engineer, Chief Medical Officer, Chief of Safety and Mission Assurance, and after [the loss of the Space Shuttle] Challenger, the Astronaut Office gets a vote. They become a Technical Authority when you are talking about an issue pertaining to human spaceflight.

What happened was we were due to complete the Space Act Agreement, then go ahead and compete for the full-up contracts for the commercial crew contract. Engineers and the medical guys really wanted us to get there, because under a contract, we have a lot more authority. Under the Space Act Agreement we were really hands off. But I knew two things. One, Boeing was not quite up to speed and it would have been a one-horse race, and like it or not, I wanted to have a fair competition. The other thing was we just didn't think that either one of the companies was to the level of readiness that we really wanted. We felt that if we went with a contract, we might not be able to hold the Congress off, and they may force us to down-select to one, and that we would end up with one provider, and that would just doom the program.

So I made the decision that we were going to extend the Space Act Agreements by one year. And boy, the Chief Engineer didn't like it, the Chief Medical Officer didn't like it; the crew was kind of ambiguous—they didn't care. And the same thing, Safety and Mission Assurance guys, they didn't like it, either, so they said no, which they can do. They can just say, "We disagree." And then the Administrator has either got to convince them that there is a plan, or go ahead and reverse the decision, and do it the way that they recommended doing it.

So Bill Gerstenmaier and I got together, and we came up with a plan that said, "Look." We explained to them why we wanted to do what we wanted to do, why we felt that in the long run it would be safer and we would be better off, and it would give us a better chance of having

two providers. And we said, "Give us six months. Look at how things are progressing, and after six months, if you are not satisfied that you have sufficient insight into what's going on, we'll go back and I'll reverse my decision, and we'll just start the competition for a contract."

As it worked out, things started rolling, and everybody got a very comfortable feeling with this "insight" thing. That was when everybody realized that we actually had more influence and more knowledge of what was going on when we were embedded in the organizations and observing what they were doing, as opposed to being up here at the top just dictating, and really, maybe they did it and maybe they didn't, but you weren't really sure. So it worked. But that was my first battle with the Technical Authorities.

WRIGHT: During the process selection, one of the comments that you made was that you really weren't part of the procurement process.

BOLDEN: Zero. I didn't have a thing to do with the process. I had no knowledge of the content of proposals nor of the deliberations ongoing. They kept me free of any accusations of undue influence or interference in the process.

WRIGHT: Explain how that worked, and how you were removed from it, but yet knew what was going on.

BOLDEN: My belief, contrary to some people, is that my job is to be the face and voice of NASA; to interface with Congress, the White House, with the general public. My job is not to get down in the weeds and make technical decisions. I should weigh in, and I should concur with the

decisions that are being made, but I have got somebody like Robert Lightfoot as the Associate Administrator, the senior civil servant in the Agency, and have got the guy running Human Spaceflight, Bill Gerstenmaier—what am I going to add of value to the decision that's that critical? As long as I am informed all along, I can steer one way or the other if I suspect anything inappropriate or illegal is going on. Bill and I didn't disagree on very much, but every once in a while we would, and either he'd explain to me why his was a better way, or he'd say, "Okay, we'll try it your way." But that happened very, very seldom.

So that was the way that we set it up. Robert was going to be the ultimate decider as the Associate Administrator [AA], since he wrote Bill Gerstenmaier's fitness report. And that was another change we made. When I came in, I wrote the fitness reports on all the center directors, on all the AAs; and I had just way more people than I felt the NASA Administrator could effectively manage or oversee or should try to do. So I transferred the reporting responsibility for the center directors and the AAs to Robert, and then we took some of the people that he had and moved them down to his deputy, and to other people. We pushed things downstream, and I had very few people that I was responsible for writing their performance appraisals. My span of control was better and it would be better for the Agency that way.

WRIGHT: So that gave Mr. Lightfoot a good insight to what was going on during those—

BOLDEN: It gave Robert excellent insight. I had learned the lesson on something that didn't have anything to do with humans. I had learned my lesson with JWST [James Webb Space Telescope]. That was the other thing that happened almost instantly. I came in, and I knew about [the financial issues with] James Webb, but in the lead-up to the confirmation hearings and everything, we

almost never talked about the James Webb. We almost never talked about any of the science things. We knew what the real hard issues were going to be. They were going to be commercial flight; they were going to be what we call SLS [Space Launch System] and Orion and Constellation going away and just going to be human spaceflight-related stuff. We were going to get a little heat about Earth science, but not a lot.

I didn't do my due diligence with James Webb, but it didn't take very long. In that first year, I started asking questions and started getting a hint that James Webb [program] was really not in very good shape. Then I got a call from Senator [Barbara] Mikulski. That sealed the deal, because here was the lead appropriator saying, "Okay, what's up with James Webb?" I went, "Ma'am, we are going to put a special team in place—an independent study group—and we are going to get to the bottom of it. We will find out what's wrong with James Webb." And boy, that was—whoo! They came back, and they said, "Man, you guys are really in trouble. One, you can not launch in 2014. You are not even close and you definitely can't produce this telescope for the price that you have told the world."

I think back then, we were at $5 billion or $4 billion. We went back and said, "Okay, if we can't do all that, tell us when we can." They used a process where they go out and evaluate cost and schedules, and they come back with, "If you want to have this probability of success at holding to the price and making your launch at this time, then here is what you need to do. You need to spend this much money, and you need to say you can launch here."

And so that's what we did. We went in and briefed Senator Mikulski, we went in and didn't brief the President personally, but we briefed OMB and OSTP for the President, and then the members of Congress. The bottom line was we weren't going to launch until 2018, four years late, and it was going to take us another $3 billion. We needed about $8.6 billion to finish James

Webb. Nobody was happy with that word, and I remember the CEO of Northrop Grumman [JWST contractor] and I went to Senator Mikulski, and she said, "Okay. This is not good news, but I'll tell you what: I am going to fight for this and this is it. There is no second chance. You guys either make this work the way you told me, or it's done, and the nation and the world will lose an incredible asset."

She said to me, "It's your responsibility." I said, "Okay. It's coming into the Office of the Administrator," which was what we did. Chris [Scolese] was still here at headquarters, but that was what really led to me bringing Robert up here to the Associate Administrator and sending Chris out to Goddard where he had direct oversight of JWST. He was acting for me. He had been the Administrator's representative as the AA. I said, "Chris, you can do this even better if you are the center director at Goddard [Space Flight Center], which is running the project. I'll bring somebody else up here." And I knew Robert was good; but I had no idea Robert was going to be as good as he really is for a number of reasons. Chris just refused to work with Lori [Garver, Deputy Administrator].

I just couldn't get them to talk to each other and he figured that was the best way to do it. But that meant we weren't going to get a lot of things done. Robert Lightfoot came in, and he said, "Hey, I can work with anybody." His first thing was to go out and say, "Okay, here is what I am doing; you are invited. You can sit in every meeting. I want you talking. Blah, blah, blah." Which I think kind of startled her. And so Robert, by saying, "You are part of the team; come on in here and get involved," it kind of slowed things down, but it kind of got the heat down here in the building, anyway.

Robert became the interface with Northrop Grumman at the corporate level, Chris was the interface with the project people at Northrop Grumman, and then we had a monthly tag-up—a

telephone tag-up—where I got together with Wes Bush, the CEO, and we had the whole team on the call. And that's how we got to where we are today with James Webb. So I had learned the lesson of James Webb when you started going back to Commercial Crew and everything else, working with the Congress.

WRIGHT: I guess you were pretty much at a tipping point there. You couldn't go back—

BOLDEN: Oh, no.

WRIGHT: —and you had to go forward with that much investment in it, because once it's gone, it's gone, right?

BOLDEN: Yes.

WRIGHT: And now, hopefully, within a year, you'll be able to see it launch, and—

BOLDEN: We will. You always keep your fingers crossed, and knock on wood, and do everything else, but, as you probably know, it's down at JSC now, in Chamber A [Space Environment Simulation Laboratory]. It had a glitch out at Goddard, where it was on the vibration table and we got something we really didn't understand, and, boy, it scared us, because we thought we had broken something and/or there may have been a bad design. They finally figured out no, it's not. We understand what happened, and it's a minor adjustment, so we can deal with that. And it just went through with flying colors.

The big thing [on the telescope] was just the test on the mirror segments themselves, to make sure that the adjustment that was built into it—these 18 mirror segments, and each one can be individually adjusted, or individually tuned, to give you the perfect image so that you won't have a problem like we had with Hubble [Space Telescope], where you had to go back and put corrective optics in or do all kinds of stuff, because you have got these 18 different segments that each represent a little piece of the mirror. It went through those tests and did incredibly well, so now that it's down at JSC in the big chamber, that'll be the last big test. And then it'll ship out, get mated with everything else [in California], go down to Kourou [French Guiana], and we'll launch in November of 2018.

WRIGHT: Yes, 2018. It's exciting. People are excited down there?

BOLDEN: Oh, yes. Oh, yes.

WRIGHT: I went to visit it [JWST] in the chamber.

BOLDEN: And it's massive, as you probably saw.

WRIGHT: Yes, and it was quite a change in building 32, as a matter of fact. It's nice that the centers worked to get this project out. I'm going to go back for a few minutes to ask about Commercial Crew, because during that time period of selection, one other piece of the bargain or the other piece of the agreement with the commercial companies was that once these that NASA has invested in were up and going, that they also will be available for commercial use.

BOLDEN: Exactly.

WRIGHT: Would you share some of those details on how you worked out these agreements? Because up until a certain point, they have to give NASA so many flights, but what happens after that?

BOLDEN: Well, the key to Commercial Crew and Cargo is that they have to go out and convince themselves and their boards that they have a business case: that they can make money without NASA. So the key part of commercial spaceflight was NASA would be what we call an "anchor tenant." We will be the reliable partner. We are going to be there. We promise you that we'll contract with you for—I think it's six flights a year, and so that's what everybody got. That says, "We don't care how many additional flights you fly with commercial partners or with commercial customers. In fact, we encourage you to do as much as you can, because that gets the cost down for us." The more they fly, the cheaper it gets to fly. So that was something we were really pushing.

One of the issues right now with Commercial Crew is that it is really hard to make the business case close. People can say whatever they want to say, but with cargo, there is tons of stuff that needs to get to space, whether it's satellites or cargo going to Station or somewhere else. But, right now it is kind of hard to find people other than government people who can afford to go to space. Until you get the costs way down, you are not going to have Mom and Pop from Atlanta, Georgia, going out and jumping on a spaceship.

So a challenge of Commercial Crew remains—how do you make the business case close? Both Boeing and SpaceX think they have done it. It's tight, but they think they have. I have no idea who they see as customers out there, but the two different companies have two different approaches, and so they think they'll be okay.

WRIGHT: Now, NASA, though, has a seat on those—

BOLDEN: If we are willing to pay, we can fly on anybody's flight. We can go back to having payload specialists—you know, take a NASA engineer that is not a full-fledged astronaut, but we have an experiment that we would really like to have somebody fly and work this experiment for us while it's flying. We could buy a seat on a regular commercial flight by Boeing or SpaceX, or Sierra Nevada, or anybody else as more companies start to do this kind of thing.

If there is an open space, say there is one extra seat, we said it would be okay for the provider to go out and contract for somebody to fill that seat. They have to provide the training for us; also they would provide the training for whoever their customer was simultaneous to doing it with us. That person would essentially sort of become a member of the crew, sort of like we used to have in the days of the payload specialists, who were not full-fledged astronauts but trained along with the crew. So it works out as a win-win for everybody: win-win for NASA and for the commercial providers.

WRIGHT: Let me ask you about the safety regimen, because some see that it might have blurred lines. The capsule is no longer a government entity; it belongs to a commercial entity. So how

does that work? Who provides the safety protocol? How about damage from fallout, if there is that accident that could happen—

BOLDEN: It's a coordinated safety effort, so is engineering. NASA Safety and Mission Assurance works with the provider to make sure that they are complying with all of the [NASA] human-rating standards that have been provided. When we decided we were going to go to commercial space, the providers came in and said, "Hey, you guys have way too many engineering standards, and specifications, and rules. We think we can provide a safer, more efficient vehicle under our guidelines, because ours, in many cases, are better than yours." We said, "Okay. We are going to take two years, and we are going to put the teams together, and we are going to let any prospective provider provide us their input on every regulation, every human spaceflight requirement standard. You can come in, and if you have got something you think is better than what we have documented, give it to us, we'll evaluate it, and then we'll talk about it. If you feel that the standard that we have is really unnecessary today because of technology or something else, tell us that. Just tell us how you would change all these standards."

After two years, what we had was we had an engineering document for commercial vehicles that was applicable to everything, whether it's Crew or Cargo; that, in addition to saying, "These are NASA engineering standards," it would say, "Must comply with NASA engineering standard 2299 [hypothetical example only] or equivalent." Each company, each provider, would marry up their equivalent standard with our NASA engineering standard. If we found out that theirs was actually better than ours, then we would just say, "It has to comply with this standard or better."

So that was the way we did it. Human-rating standards, we did the same way. It took about two years to come to an agreement on, for example, what are we going to use for the real standards for flying humans and for flying cargo? The two safety organizations—from the provider and NASA—oversee that.

They do their own final Safety and Mission Standard Requirements Review or something like that. But it's the final review from the Safety and Engineering folk that says this vehicle is ready to go fly. The provider does one, we sit in on that; then we do a second one that says, "Okay, we heard what they said. We have got a problem with this, so we are going to go back to them and tell them they need to satisfy this shortcoming." We still get the final say on whether or not we are satisfied or not. They decide whether they are going to fly; we can say no. And they can say, "Well, we are going to fly anyway." The choice we have is we say, "Okay, but you are not going to fly for us. So you can fly that vehicle on this flight, but it's not going to be a NASA flight. We are not going to have a crew, and we are not going to put our cargo on it." That's sort of the way that we made this arrangement to get around NASA not having any influence over the provider.

WRIGHT: It infers a really close relationship of getting along, doesn't it?

BOLDEN: It does, I think that started with the PIT teams. The biggest thing was us recognizing that it's not just the government that thinks about safety. Commercial entities think about it, and they generally think about one extra thing that we almost never even worry about, and that's cost. They recognize well that if they have an accident, that's going to send their costs through the overhead, so it is best for them to make sure they don't have an accident. They look at safety from

two perspectives: one, you want to save life, but you don't want to cost the company any money that we don't have to spend. Generally, we don't think about that. We just, we will not let anything happen to anybody. You can say that that's good, and we have a higher standard than anybody else; I am not sure where we would be if we also had to worry about the impact of cost if something went wrong the way that the commercial provider does.

WRIGHT: During this time period, when Commercial Cargo started up, a lot of it was set up with Space Act Agreements. When Commercial Crew started, it had some, but some was relegated to the FAR [Federal Acquisition Regulations]. How was that determined? And regarding the legal situation, explain the specific guidelines that you wanted to make sure got covered from one to the other.

BOLDEN: Eventually, we were going to switch to the FAR. We were going to get out of Space Act Agreements for Commercial Crew especially. It was just a matter of when do we make that transition. And I go back to the story about the conflict with the Technical Authorities because there was a difference of opinion as to when you make that transition. The reason that we have to get into a FAR is because we are now starting to contract for a service, and we are not an investor anymore. When we flew the first few Cargo flights, we were an investor. We were going along with a developmental company, and putting our money up to make sure that, to the greatest extent we could contribute, they were successful. Once they were successful and they decided, "Okay, now we are ready to go make money, and we are going to charge you," then that's when we switched over to the FAR based contracts. So it was easier to do it for Cargo, to be quite honest. Crew took a little while. Yes. Okay.

WRIGHT: Your main provider of crew transportation currently is the Soyuz.

BOLDEN: Yes, for now.

WRIGHT: It's, I think, what? NASA pays seventy-one million dollars, give or take, for each trip to the Station?

BOLDEN: And that was the other thing that we looked at. We said, "Okay, how much do we know about Soyuz?" It turned out we actually know more about Dragon and the CST-100 [Starliner] than we will ever know about Soyuz. Although we have been flying Soyuz for decades, we didn't have the insight that we do with our two American products, because the Russians presented data, and what we did was we accepted [their] experience as that's okay.

It's sort of like applying to be an astronaut: there is a requirement that you have three years of operational experience. For somebody that's a test pilot or somebody who has a PhD, that criteria is satisfied, because we accept they have been working for longer than three years in an operational environment; they have the experience we need. Somebody who is not a test pilot or doesn't have a PhD, then they have got to go somewhere and work for three years and demonstrate to us their ability to do that.

With SpaceX and Soyuz—or even Boeing and Soyuz—you look at the hundreds of flights that have been flown on Soyuz, and all the data that we have as a result of those flights, it's much easier for us to accept an explanation from the Russians when we see something that doesn't look right, or we can go back and do our own reverse-engineering and figure it out. In the case of the

few accidents that the Russians have had, with Progress or with other vehicles, we have not gone back and flown until we satisfied ourselves through our own engineering analysis that, yes, what they said was the problem really was the problem. And we have got access to tons of data, flight data and everything, so we can satisfy ourselves that we know what really happened, and it's okay to go fly again. Yes.

WRIGHT: Will Soyuz be continued as a contingency, the relationship with the Russians—

BOLDEN: Oh, yes.

WRIGHT: —to have whenever they are up and going?

BOLDEN: In fact, the plan—and when you talk to Bill [Gerstenmaier], you can ask him to confirm it—but the plan when I left [NASA as Administrator] was the primary crew vehicles will be CST-100 and Dragon. Because we don't ever want to find ourselves in a situation where we have got to evacuate the Station because we have an injured crew member, we always want to have the "out" of just bringing one vehicle home. If that vehicle happens to be Soyuz and we have an American crew member on the Station, then we want to know how to fly Soyuz. We want to be able to have a crew member on it.

The big difference is we won't pay. There will be no exchange of funds. It will be just like we do with every other partner on the International Space Station. Right now, the Russians are the only ones that we pay something. With the rest, with the other partners, there is no exchange of funds. That was the crux of the international agreement that made the International

Space Station so successful: you contribute something, you get a crew slot; you contribute something, you get time in the laboratory; you contribute something, you get this, you get that. With the Russians, it was, "No matter what you do, we'll pay you." We'll be moving away from that. They will get to fly on our vehicles at no cost, because they are providing other services, and we will still get to fly somebody on a Soyuz.

WRIGHT: Will the Russians be able, also, to contract with the commercial providers?

BOLDEN: Oh, yes. They can do that now. That's the thing: they have been doing it for a long time, flying guest cosmonauts and the like. They control their vehicle, and they can take somebody along. Now, if it's going to Station, then the Station partners, they have to concur that it's okay to fly this particular person. They do get a veto, and that has always happened when the Russians have gone out and gotten a commercial "rider," if you will. Yes.

WRIGHT: Speaking of rescues, when I was reviewing information about Commercial Crew, I remember you talking one time about a safe haven. Is that component still being worked?

BOLDEN: Yes. As it is right now, Station is the safe haven. What we are going to have to figure out is, if you go to where I think we want to go and we will go, you will have multiple orbits, so Station will no longer be the safe haven, and we are going to have to figure out how we provide for that. My guess is we'll do something similar to what we did after [Space Shuttle] Columbia, when we started having two vehicles on the pad at one time in case something happened during ascent and they weren't going to Station. It came about when we did the final Hubble Servicing

Mission, because they were not going to Station orbit, so we had to have a way to get to the crew. The safe haven became the crew vehicle in which they happened to be at the time, until we could get a rescue vehicle up there. My guess is we'll probably do some arrangement like that with the Commercial guys, or my guess is they will always be going to some platform, whether it's human-tended or human-occupied, because that's going to be the source of their revenue, is they have got to be taking something somewhere. Unless it's a satellite, if it's got people on it, they are probably going to one of these human-tended or human-occupied platforms. So that'll serve as the safe haven until you can get somebody back up there to rescue the crew.

WRIGHT: When this whole process started, you certainly were hoping that you would be completing "Launch America" before you departed the agency.

BOLDEN: I thought we'd be doing it in 2015. If Congress had appropriated the funds with the 2011 budget when the President first started asking, we probably would have launched—we would have launched pretty close to 2015. But with every year that Congress refused to fund the program—to fully fund it—we were delayed another year.

That's why right now, my guess is that we'll fly in 2018; I don't think it'll be—I would be surprised if it's a revenue flight. It'll probably be one of the two checkout flights: one that's no crew onboard that'll go to the Station, demonstrate that it can Station-keep and rendezvous, dock, and do all that kind of stuff that it needs to. And then we'll go back, fly the next flight, and that'll be with a crew, and that'll be it. They will be certified, and then they'll start making money. But my guess is that'll be late 2018, maybe early 2019.

WRIGHT: When the decisions were made to contract with these companies to provide the end-to-end Crew Transportation System design, it began a massive shift in NASA's human spaceflight culture; it was seen as a cost-effective alternative. Now that you are on this end of it, from the years of development, through it all, do you believe it is still going to be that? And why?

BOLDEN: I do, because what you have is a firm, fixed-price contract, you know how much it's going to cost you, and you can control that. If you don't say, "Okay, I want additional kinds of things," then the price won't change. So I think it's very cost-effective.

For what we have paid for Cargo and Crew up to this point, it doesn't even begin to approach what we were paying to maintain Shuttle. Shuttle was $2 billion a year whether we flew it or not, plus the cost of each launch, which was somewhere between $400 million and $500 million per launch. It's a significant cost savings from what Shuttle was costing.

WRIGHT: Is there a way that you can assess the benefit or the value of the innovation that's come from this? Shuttle was specific, so you knew what it was going to cost. This approach was an innovative and a different way of doing business; some of the value is not tangible. How would you assess that?

BOLDEN: I think over time you will be able to. You will be able to put metrics in place—when we asked the National Research Council to go off and do the last human spaceflight study, we asked them to come back and give us a value—if possible, a monetary value—for human spaceflight, for sending humans out to explore. After about a year, they came back, and they said, "Hey, we got good news and bad news." We said, "Okay. Give us the bad news first."

The bad news was we don't know how to put a value—a dollar value—on human spaceflight. There is no return on investment that's easily identifiable like cargo, where you say, "Okay, you have got this much value in a satellite, you are going to put it in orbit, and you are going to handle 1,000 customers. So the return on investment is going to be the cost of that satellite taken away from whatever profits you make by operating the satellite for television, communications, whatever else." We don't have anything like that for human spaceflight, what's the dollar value of doing something that's never been done before? How much is it worth for a scientist, like [Kathleen] Kate Rubins, who did gene [DNA] sequencing onboard the Station? Having a doctor, a qualified doctor, do gene sequencing in space that's going to benefit human beings down here on Earth? We don't know how to put a value on that yet. Maybe someday, people will say, "Okay, well, we have got X number of new drugs that's worth this many trillion dollars, and it costs this much to launch them to space on 10 CST-100 flights, so that's the return on investment." You may be able to do that one day. We can't do it today.

Yes, it's the challenge of human spaceflight, because a sizeable number of people want to know what the return on investment is. They have learned this term, and they don't want to put their money in there—to include their taxpayer dollars—unless they know how much they are going to get in return for doing that. And it's just hard to do that for human spaceflight.

WRIGHT: Well, you segued right into the next segment, about the International Space Station. When you walked in the door here at NASA Headquarters, the Station wasn't finished. But it reach completion, it is fully operational, and its time for operational life has been extended. But, at the time you started, what were your expectations for the Station? What did you want to accomplish? What did you want its legacy to be when you walked out this door?

BOLDEN: The one promise that we made to the President was that we would comply with the law that said, "You will finish Station by 2010." He established that as his—again, he gets the blame—but what he did was he said, "Like it or not, the Columbia Accident Investigation Board recommended—and the NASA Administrator accepted, and we put it in law—that we are going to complete Station by 2010, and then we are going to phase the Shuttle out. That'll be it. We are only going to use the Space Shuttle until the Space Station is complete." We said, "Okay, that's what we are doing." We did have to go back and ask for two additional flights, for different reasons, and another year.

As it turned out, instead of phasing it out by 2010, we ended flight in July of 2011. The benefit we got was the AMS, the Alpha Magnetic Spectrometer, into space, which was something that we had been promising we were going to fly, I think, dating back to [former NASA Administrator Daniel S.] Dan Goldin. We just never were able to fit it on a flight, or never able to find a flight where somebody would pay for it, or what other reasons. I think actually, President [George W.] Bush had approved it before he left office, and then President Obama said, "Sure, we'll go ahead and fly this thing." And so we flew STS-134, and put the Alpha Magnetic Spectrometer on there, and it's doing incredible stuff. People are still hoping we'll see some Nobel prizes come from that.

The other thing we got, though, was the ability to forward-provision Station for the rocky times that we anticipated we were going to have when Shuttle was gone and we had to rely on commercial means to get cargo to the International Space Station. Every time we met some roadblock in bringing Commercial Cargo onboard fully, I would go to Bill Gerstenmaier and I would say, "Hey, how long can we hang on?" He said, "We are in good shape." He said, "We

have got enough on Station to carry us through the next three years," or something like that. But that was because he had planned it out, and he had used Shuttle wisely, and had said, "Okay, we are going to take those last two flights and we are going to just put everything on there we can possibly imagine: spare parts; food; clothing—you name it." And since then, we have used some of those spare parts already. I think we changed an ammonia pump and did a lot of other related stuff. So they were pretty smart in doing all that.

WRIGHT: Good planning. Earlier, you mentioned what Kate Rubins had done. What other accomplishments are really proud of that came out of Station while—

BOLDEN: I didn't have anything to do with it. They were going to happen. But, yes, things like producing a salmonella vaccine that is—I don't think it's in human trials yet, but it's on track—to enter human trials. That'll be revolutionary and something that comes from Station. Think about that—knocking out a disease or having a vaccine to treat something like salmonella from work done in the microgravity environment of space, where you can take proteins apart and you can do types of research that you can't do down here.

It's a lot of study going on now. We are finding out that the kinds of things that we see with an astronaut in space almost always have some direct correlation to something that's going on down here on Earth. Turns out that what we thought was just a problem with [astronaut] vision while in space, people other than just spaceborne people sometimes suffer the same maladies. Hyper cephalic kids with enlarged heads have the same kind of fluid in and around the brain that an astronaut does in the microgravity environment of space, and sometimes they suffer those kinds of problems. We are looking at Alzheimer's.

There is a process now called "nanoencapsulation," where we have been able to produce these incredibly uniform nanocapsules. They are just microscopic balls that are hollow on the inside. What medical science does with them is they put a chemotherapy material, a drug, inside the nanocapsule, and insert the nanocapsule inside the tumor. Now we can actually defeat cancer in a human being if we can identify where the tumors are, put the nanocapsule in the tumor, and it destroys the tumor without affecting the rest of the body, or making the rest of the body weak.

I just love going and talking to the Station folk about what CASIS is doing, the—CASIS, the Center for Advanced Science in Space, CASIS. Both Congress and OSTP pushed us to stand up this independent organization. And we took a lot of pushing. At first, NASA did not want to relinquish control of the U.S. segment; "We know best what should go on there. What do these independent guys know?" Well, it turns out they are pretty good. They are businesspeople, for one thing, and so they know how to generate business. We don't always agree on some of the things they want to do, particularly when it comes to advertising, that bothers the lawyers. It doesn't bother me.

I envision—and my hope is the Chinese will force us to do it, to be quite honest, because they are now talking about Tiangong-2 being the nucleus for their space station that they want to have operating by 2020, 2025. My guess is they will go to human-tended platforms. They are going to do materials processing; they are going to do pharmaceutical development. And we are learning through CASIS that we can do all that stuff. Where we are having trouble is getting the commercial entities to say, "We agree. We are going to step off Station and we are going to launch a platform that'll be in low-inclination orbit. Just going to launch due east out of the Kennedy Space Center; it'll be in 28.5-degree inclination orbit." Because you don't need to be in the Space Station orbit. In fact, sometimes you don't want to be up there. It's so much easier to just launch

due east and get right into orbit, and you can be any altitude you want to. You can go a lot higher if you just launch due east, because it takes a lot of energy to make the turn to go up into the Space Station orbit, and you lose some of the altitude that you would be able to put things way out to study.

I think we are going to have a series of constellations of tended vehicles in multiple Earth orbits in the next 10 years or so. The Chinese are making steady progress. They don't do anything spectacular. They just kind of say, "Okay, this is what we are going to do," and they just get there.

WRIGHT: But it's that consistent commitment, isn't it?

BOLDEN: Yes.

WRIGHT: What were your plans for the Station for extending its life? And where would you like to see it go?

BOLDEN: I would like to see it go away in 2028. You know, 2024 is where all the partners have agreed to date. We agreed, we got President Obama to agree to extend Station to 2024. That says, "Yes, we are going to make the commitment to keep operating it, and keep funding it and everything else," but we don't put any money in the bank for it. We could come up next year, and the U.S. could decide that we are getting out.

The Europeans don't work that way, nor do the Japanese. The reason it took the Japanese and the Europeans so long to sign on for the extension—the Europeans just did it this year, or late last year—was because when they make a commitment, they take money and they put it in the

bank. So it's not only a promise that they are going to stick with it until 2024, it is in their budget and it is funded. That's the good thing about the way the Europeans work. Even if we step aside, then the Europeans will still be able to operate. Kind of hard operating if we are not there, but engineering-wise, it could go to 2028.

By then, we should have a commercial low-Earth orbit infrastructure well established. If we don't have something to replace Station by 2028, it isn't going to happen, anyway. We will not have been able to convince commercial entities that flying stuff in space, and doing work and production in space, doing 3D printing, printing parts for rockets—doing all of that kind of stuff is really valuable for one thing, but also important. I think we can convince them, because there are more people starting to talk about this, and they are seeing that there is economic value in doing it.

I think we are going to be okay, and so 2028, the International Space Station as we know it should go away. The plan is to kind of break it up into individual pieces that are big but not too big to burn up during reentry. Some of them, like the JEM, the Japanese Experiment Module, are new enough and state-of-the-art enough that you could actually take it apart from the rest of the station and leave it up as a stand-alone platform and do work there. Or you could put a power and propulsion module with it, a new one, and the Russians are talking about sending up a new power and propulsion module—they are talking about it, anyway—in the coming year or so. You could combine that, say, with JEM, and then it becomes a new stand-alone space station. So I can see all those kinds of things happening.

WRIGHT: Do you see the Station as it is and between '24 and '28 without the United States? Do you believe that—

BOLDEN: No. The integral partners are the United States and Russia. I asked the question once, of our guys and the Russians, because the Russians made the decision that they were going to decrease their crew size by one, and we went, "Man, what about the Russian segment?" And I asked the question: "Can we run Station? Could the U.S. operate the International Space Station all by ourselves, given our international partners there to help?" And everybody said, yes we could—we could figure out how to operate the Russian segment—but it's not worth it, because it's old, and it's going to go away, and so we'd put a lot of time and effort into training crews to operate the Russian segment when—why don't we just talk the Russians into staying in so that we don't have to worry about it? And I think that's where we are now: trying to make sure that they remain a reliable partner.

Now, the unknown is what are President [Vladimir] Putin and President [Donald] Trump going to do? They could throw a monkey wrench into all our plans. The good thing is for 17 years now, in spite of everything else that goes on, we have been able to work cooperatively with Roscosmos, the Russian space agency. And I think it's because of the personal friendships involved. Sergei Krikalev now runs their human spaceflight organization. He and I flew on my last flight in 1994, so not only were we crew members and still very good friends, but we know and understand each other. Bill Gerstenmaier spent a year over there being mentored by the Russians, and so they know him, and respect him, and trust him, and he the same way around.

So I think as long as we can continue to do that, I think we'll be okay. But I can't see anybody operating Station without the Americans there. The U.S. infrastructure is just massive. You have Mission Control, and we could shift some control to Moscow, but I am not sure how long they could do that. And they don't have anybody who knows how to operate the parts of the

Russian segment. Now, the Russian cosmonauts want to, and every time we go to these different technical sessions where the astronauts and cosmonauts come together with the flight controllers and all that, you get a whole different conversation. They want to be much more aggressive than we are in leadership. They want to just have one space station, and they want to be able to move freely from Russian segment to U.S. segment, and "Okay, we need somebody to go over there and do that in the Russian segment," "Okay, I'll do it," and just have a crew member go do it. We don't do that today.

WRIGHT: You have spoken a lot about international friendships and relationships, and 50 years ago, we—the United States and other nations—entered into a treaty for peaceful uses of outer space. Now there some talk has begun about changing the wording because of all the commercial possible potential or prosperity. How will that impact what's was created? How does it change the current culture?

BOLDEN: It's not just the introduction of commercial stuff into space. It's the gradual weaponization of space that's also going to impact what's in that treaty. We are notorious for helping to write a treaty and then not sign it because we don't like the bad things that could happen if we want to do something and it's in violation of the treaty, so we are just not going to sign. But what the U.S. Space Command is working on now—and I think it's going to end up being a joint civil/military action, at least from the U.S.—to decide how we should restructure the current international space treaty, and how do you get militaries of the world to agree to—even though warfare may occur, then one of the primary intents of peaceful uses of outer space is to keep it from becoming a hostile environment. That mainly deals with the rapid growth in orbital debris.

Even today, when we talk to the Chinese and we talk to the Russians, we have meetings all the time with them to include the militaries that say, "Look, nobody wants to make low-Earth orbit untenable by creating some massive amounts of orbital debris out there. Let's be smart in the weapons that we develop." You would hope that we would say, "Let's be smart and not develop space weapons," but I think we are too far gone for that. But almost never do nations go into combat without some rules, and there are generally rules that try to benefit the majority of humankind, as opposed to the combatants are disposable. Most countries involved in warfare say, "We are not going to do this forever. We feel it's necessary to go to war right now, but let's hope we can figure out a way out of this. But in the meantime, let's not destroy the world, so that we have nothing to go back to once we come to our senses and reach a peace agreement, or something like that."

My guess is the next outer space treaty is going to have to take space weapons into effect, and it's going to have to try to get potential adversaries to sign onto some prohibitions that "this shall not be utilized in space." It's like weapons of mass destruction—when you talk about mustard gas—those kinds of things are outlawed, and most nations of the world abide by that. One of the reasons we have all the problems in Syria is because they don't seem to care, and so they don't abide by any rules. But those rules have been long established, and most nations have abided by them, so you would hope that somebody will sit down and restructure the present international space agreement, and it'll take care of that.

WRIGHT: Let's talk about deep space exploration, because Constellation was canceled, but yet, you managed to redesign, repurpose, and not only keep NASA in human space exploration but

you also kept much of the workforce. Talk about how that's worked, and then, of course, the progression. You have had a flight test; you have lots going on.

BOLDEN: That was interesting and that came in the first two years. That was a part of the rough road in the first two years. We had to spend a lot of time—we had to spend almost all the time—on that end of Pennsylvania Avenue (pointing toward the White House). Congress was all in. They didn't want to get rid of Constellation. But as we explained more and more [to folks in the White House] what we wanted to do—that we really wanted to avoid saying we were going to "terminate" Constellation. "Termination" is a horrible word, and they don't let us forget it, either, because you have this thing called "termination liability," and we were accused of purposefully terminating it so that we could keep industry from ever building a big rocket because of all of these termination liabilities. We got accused of a lot of different things.

We had to go in and work with both OMB and OSTP, and then others in the White House who would talk to the President, and say, "Look, I know what the President wants. I know what he said and the President wants us to be involved in deep space exploration. I don't care what you guys say. And to do that, nations build deep space exploration vehicles. That means that NASA has to be a part of that, because to start with it's too risky, too expensive and everything for you to hope that any commercial entity is going to do that, so get that out of your brain. That isn't going to happen."

Then, we had to kind of hold the commercial guys' feet to the fire and say, "Okay, you said you were going to take over [cargo resupply]. Get flying." And as you remember, it was really hard. So we said, "Okay, until you start flying to the Station reliably, quit talking about deep space. Don't worry about it. We'll get it started, and then we'll get you to come along."

We made an agreement with industry. We said, "We are going to build the initial deep space exploration vehicle. It'll be something." We came up with SLS (the Space Launch System), and we convinced the President—or people around him—to keep the good parts of Constellation and the best part of Constellation was Orion. And so, although a lot of people—like John Young—thought Orion was way too big. He wanted something much smaller, like an Apollo capsule. I am not a spacecraft designer, so I don't know, but people convinced me, for a lot of other reasons, that we needed a much bigger vehicle that we could use for really deep space exploration.

On April 15, 2010, President Obama went to Kennedy [Space Center] and gave what I consider to be a major space policy address. I think one of the biggest things we were able to do was convince his advance team that it would be okay for him to walk past the Orion crew module and to talk about Orion as the future vehicle for carrying humans to deep space. And then while I had no idea that he was really going to say—"Mars"—but did on his own. He started talking about going to Mars, and he gave a date. He talked about asteroids—that one caught us by surprise, but I found out later that we had people over here who had all these ideas, and they were feeding them to people in the White House, unbeknownst to folks on the ninth floor. More ideologues, and so that happens a lot.

So the President went down to the Kennedy Space Center, and it turned out to be what I thought was an incredibly good major space policy address. Because things had gotten so hard between the White House and the Congress by then, nobody paid any attention to it as a major space policy address. I thought it was very similar to [President] John Kennedy's Rice University speech where he said that we are going to the Moon by the end of the decade, and that we are going to do it not because it's easy, because it's hard. President Obama said that kind of message

and he did give a date. He said by the 2030s, and 2025 for an asteroid. We took him at his word, and we started marching off.

We had to continue to convince OMB. We knew what the President said, but they kept telling us, "Yes, but he didn't mean that." We said, "We don't give a crap what you think. This is what the President said." The good thing was Congress heard it, and you had people again like Kay Bailey Hutchinson, Bill Nelson, Senators Shelby and Mikulski, and members in the House who said, "We are going to Mars." It took a while, but over time, you got more and more people to say, "We are really going to Mars."

One of the things we did was to utilize Ares I. It was really important to do that for a number of reasons. One, it kept people working; that wasn't the main reason, though. The main reason was it was the most heavily instrumented vehicle we had ever launched, and so we were going to be able to get data from that launch that we would be able to give to the commercial entities, because they were going to be the ones to do what we were designing the Ares I to do. This was against all desires by mainly OMB—OMB fought Ares I, they wanted it to just die, go away.

If I put myself in OMB's place, they were worried about two things: one, that it was going to be successful and that it was going to mean that SLS and Orion were going to be even harder to kill; two, the other thing they worried about if it was successful that people would say, "Well, why did you cancel Constellation?" And we said, "Hey, I understand that risk. It is going to be successful, because we don't go launching a vehicle for it not to work. So we intend for it to work. We made the decision, and it was a good decision. We are not launching this to demonstrate that we could have flown Orion on an Ares I. We are demonstrating that we can do this and we are

getting all this data." That's what we did and all the concerns eventually died down after the mission after it was successful.

What we did next I thought was incredible. In 2014, we flew Orion the first time. And we made the decision that because SLS just wasn't moving fast enough, we were going to use another launch vehicle, which was the Delta IV Heavy. We just wanted to launch Orion to see if we could get it out into deeper space than we had been before and see how it can control itself. Could it operate autonomously? Could we send commands to it and make it do what we want it to do? Could it withstand the radiation environment outside of the magnetosphere? And then the most important was, can it survive reentry?

The profile was planned such that Orion would do two orbits of Earth, get out high enough that it would be exposed to all this radiation for a couple of hours, and then be far enough out that when it came back to Earth, it was going to be going hotter than blazes to get this incredible heating that we knew the spacecraft would get coming back from the Moon or back from Mars. And it passed with flying colors, and that was a really, really good day for everybody when that worked.

The other part of this that is not lost on me is the partnerships. It brought the Navy back into the game. Boy, I'll tell you, I went out to San Diego and got on the USS Anchorage, which was the ship that did the recovery. These are kids. I was out there and I went, "Holy shit! These are kids!" Some of them are almost 20 years younger than my son. They are out there driving these billion-dollar ships. What really got me excited was when I went up on the bridge on the day that we did the final practice recovery, you had this crusty old captain sitting in the captain's chair, but the person running the ship was a young lieutenant. She was a female lieutenant from Old Dominion University, and I went, "Holy gee! Only in America!" Her helmsman was this young lady that looked like she had just come out of high school, and here they were driving this

doggone ship, getting ready to go pick up my spacecraft. I mean, I was just—I was moved by it. And they were so excited. And—

WRIGHT: They inspired you, didn't they?

BOLDEN: Oh, they did! They really did! They had the divers in the water. They had a lot of problems getting Orion in. So we learned a lot of lessons from that, which, they were able to go back and do some redesign and change the technique for getting the vehicle into the well deck when we really did fly Orion.

When that flight happened, it went flawlessly. But it taught you again, this is why we practice, and this is why we train and do everything else. *That* part was not lost on me.

It also pointed out to me that this is generational. These were kids, and they were excited about the prospect of going to the Moon and being able to play a role in that mission. It was their grandparents who were the last people that identified with the space program the way that they are now doing. I thought that was huge, and there is a whole generation in-between them and their grandparents that just don't get it, because they didn't have an opportunity to see anything go outside the Earth's orbit. They had the Shuttle, but they kind of lost interest in Shuttle even before the program was over; it just became too routine, or something like that.

Those were really important, and what we were able to do gradually, bit by bit, was begin to show people hardware. When we talk about going to Mars now, you are not talking about drawing boards anymore. You are talking about cutting hardware. We have multiple launch vehicles, multiple SLSs, coming together down at Michoud [Assembly Facility, New Orleans, LA]. They have multiple vehicles—Orion—that's now under construction down at the Kennedy

Space Center and out in Colorado. Then you look at the commercial guys with Boeing having four CST-100s in various stages of production right across the road from KSC in what used to be an Orbiter Processing Facility.

I was down in Florida for the Astronaut Hall of Fame induction a couple of weeks ago, and when we were going out for the ceremony, they took us by the Blue Origin facility [Cape Canaveral]. This thing is massive. It's like the Space Station Production Facility—that's over there in the industrial area at KSC. It's coming up, and it's commercial, and it's Jeff Bezos, and he says it's going to be finished in December [2017], where they will start cutting metal and building hardware. That's a significant investment, and it's done by somebody who has a lot of money because he knows how to spend it. He has made an investment, and it's a good investment. And so that was really encouraging, to see that.

You can see the commercial aspects really catching on. [KSC Director Robert] Bob Cabana has done just an incredible job of just completely changing the face of KSC to make it a multi-user space facility. When SpaceX launched from [launch pad] 39A, that was another historical day, because we now had come complete circle from going to the Moon back to commercial launches from that same launchpad.

And so, yes, that is the face of the future, and that's the way we are going to do this. Commercial companies are going to help us get to Mars. [NASA is stepping away from owning and operating launch vehicles; we will not be conducting the launches in the future. We won't own and operate space stations, but we will pay to utilize facilities in Earth orbit to conduct our research and train our astronauts for operating in the microgravity environment of space so they are better prepared to venture on from low-Earth orbit to deep space destinations.] It all comes together, so it's a pretty good time, actually.

WRIGHT: It is. And again, that segues into the whole aspect of reaching Mars. So share some of what as Administrator you were able to put in place to get one step closer to Mars?

BOLDEN: I will take credit for one thing. I was just a pain in the ass to everybody over in the White House. They just wanted Mars to go away. Two things they wanted to go away: they wanted Mars to go away, and—well, they wanted that to go away more than anything—and they wanted China to go away. The President wanted Mars, and the President wanted China, and nobody else around him over there did, except maybe Dr. John Holdren. They just kept trying to make it go away, and I wouldn't.

I had almost a whole year when I couldn't do any public appearances. You probably don't know that. It was in my first year. I did an interview with *Aviation Week*. In the interview, we talked about two things that got me in big trouble. One was I talked about China and that one of these days, China is coming. The other one I talked about was Mars, and boy, that did not sit well with folk in the White House who were trying to get the President to forget about both of these things. And so they called over and told the [NASA HQ] Communications Office, "Okay, that's it. Cut him off. He is not going out."

WRIGHT: "He is grounded?"

BOLDEN: "He is grounded." And then we brought David Weaver in [as Associate Administrator for the Office of Communications] over the course of all that, and he said, "This is crazy." Because

he had connections over in the White House Communications office, then he and [Chief of Staff] Mike French, started working on it, and so I got un-grounded, and we got back out.

It was just by me being a pain in the butt to the Executive Office of the President on Mars that we were able to hold on until people realized we were really serious. And for the international partners to buy in. Although we tried to meet every quarter with the heads of these [international partner] agencies, we weren't able to quite do that, but every time we met, we got to the point where we would spend time talking about the future: talking about exploration and about deep space exploration. I would ask them all the time, "Where do you—look, we have plans, and we know what we'd like to do, but we aren't going anywhere unless we have a team. So what do you all want to do?" We'd go around the table, and everybody would say, "We are going where you go. Everybody knows we are going wherever the U.S. goes."

And so everybody started talking about Mars, and some nations more enthusiastically than others. The European Space Agency [ESA], because they are the leader right now—Johann Woerner [ESA Director General] really is enamored with the Moon, and a Moon village, which is a conceptual kind of thing. He wants to go to Mars, too, but he just thinks that going to both the Moon and Mars is something that Europe couldn't do. I said, "I agree with you. We can't do that. The United States can't go both back to the surface of the Moon and to the surface of Mars. We need somebody who will assume the lead—take lead responsibility—for lunar landings and stuff." Still haven't been able to get anybody to step up and say, "We'll do that." That's where I think the Chinese are going to be invaluable, because they have said they are going to land on the surface of the Moon, and they are going to land with people. And so we have talked about collaborating with them: "We'll team up, we'll support you. You don't even need a heavy lift launch vehicle: we can get your lander there on SLS," and things like that. All the basics are in place if we can just

get permission to start working with them, and sort of integrate the plans that we both have right now.

The international partners are trying to figure out what to do when we step away from Station. They are going out and testing the waters with the Chinese, which I think is good. Because everybody is not sure what we are going to do; we always encourage them to do it. The Chinese are not marking time right now, they are gathering international partners.

WRIGHT: I believe when you were creating the SLS, one of the comments that you made along the way was that you were creating a system to take you somewhere, not necessarily just to a place.

BOLDEN: Yes, yes.

WRIGHT: Do you believe still that was a decision that gives you a broad range of options?

BOLDEN: Yes. One of the reasons I said it would take us somewhere was because we dared not talk about what we thought people were going to find with SLS. We were convinced that the Department of Defense, that the intelligence organizations, other people, have bigger and bigger spacecraft that they need to get to space. So we felt that somewhere down the line, there were going to be other users.

The other group that we counted on was the science community, because we were looking at Europa. The Europa mission that Congressman [John] Culberson, when he became the Chairman [House Appropriations Subcommittee on Commerce, Justice and Science], made very

clear: "You are going to do this whether you want to do it or not." And so we said, "Okay. We'll do Europa."

The Planetary Science guys that do all the planning and all of the calculations on how long it takes, and what is needed for missions, they started taking a look at SLS, and they went, "Wow. Man. SLS, with its lift capability and the advanced upper stage, we don't even have to go swinging around Earth and swinging around the Moon. We don't have to get all these gravity assists—we can just launch and go straight to Jupiter. Instead of taking five years, we can get there in three. Man, that would be absolutely incredible. So let's baseline SLS for the Europa launch." And we said, "Ah, not so fast. Let's not do that."

But they went and told Congressman Culberson. He tried to put it in the budget, and mandate it, and we said, "Please don't do that. We think that we'll end up selecting that vehicle, but we don't want to have to fly on it if it turns out that that's really not the best way to do it. We are confident that it is going to be the best launch vehicle for a deep space mission, whether it's for people or satellites, but don't force-feed it. Just let us go through all the analysis and go through development and analysis. Let's fly the vehicle first, and then we'll come back and say, 'Yes, we're right. Yes, we can do this.'"

And so that's where we are now. We are on the verge of baselining SLS for our Europa mission. And then you'll find that the science community will use it. Once they have that successful mission, then they will start using it more and more. So that's kind of what we were talking about when we said it can go lots of places, not just to a single destination. Yes.

WRIGHT: Yes. Let's talk, then, about science and planetary missions. I believe you once described science as being the way to reach new heights for the benefit of all mankind, unraveling the

mysteries of our universe to find out where we came from, where we're going, and whether we're alone in the universe of Earth, which, the James Webb [Space Telescope] is hoping to do. But you also funded a number of other missions, and believe there is so much more to do. Tell us about how you determined where to go, and how you wanted to get there, and about those missions you hope that will bring the greatest information back.

BOLDEN: I think it's the combination of OSTP pushing on miniaturization, NASA using Space Act Agreements, and just really smart people down in SMD. We started looking at the commercial model and said, "Everything we do in Planetary Science doesn't have to be a big $5 billion spacecraft." The first challenge we gave them was Europa. I said, "Okay, we are going to set the limit at $2 billion. If it's more than $2 billion, don't even bring a proposal back. We are going to go to Europa, and we are not going to spend more than $2 billion." The community went out and started looking, and they found that we don't have all the talent here at NASA to do this, so let's go out across the world, really, and see if we can get some other proposals.

They started seeing that when they did it that way, they received some really incredible ideas, whether it was using CubeSats for some things—and now people talk about putting a CubeSat on a Europa mission—or a swarm of CubeSats that when you get in orbit, you just release all these gazillion CubeSats that eventually end up just kind of crashing into Jupiter's moon, but in the meantime gathering all kinds of data and sending it back that we otherwise might not be able to get, whether it's landing site ideas or other kinds of things. I think by virtue of success of commercial space commercial cargo, and then starting to do more and more CubeSats on Station, people started thinking smaller as opposed to always bigger.

I think most people believe you still have to have a big mission [in cost and complexity], something that was referred to as a "flagship." We don't always have to have a flagship mission that means big size and cost. "Flagship" means we discover things that nobody expected. We discover these marvelous things. And we believe you can have a pretty cheap mission sometimes that goes out and makes a discovery that nobody expected. Look at, the exoplanets that did not come from a flagship mission. That came from a mission that they did out at Ames Research Center [California]; almost didn't make it because planning was kind of faulty in parts. They got help from other centers and all of a sudden, we have this relatively inexpensive planet finder that's just revolutionizing the way that we look at the universe, because it's discovering all of these exoplanets and more.

The science community began to believe that they could use the whole spectrum of sizes and shapes and capability and make the same kind of discoveries that before they thought, "Only a flagship mission can do that." So that really helped. Jim Green played a tremendous role in pushing that, as well as folk in Lockheed [Martin Space Systems], guys out at Ball [Aerospace]. It was just the collaboration among industry, NASA, and some of our international partners that said, "We can do these things, and we can get more bang for the buck if we start focusing on the quality of the data and discoveries we make as opposed to just the quantity that we get." Yes.

WRIGHT: And it seems to have gathered quite a bit of excitement from many people in the country.

BOLDEN: Oh, yes. I go back to CubeSats. They are problematic in one respect, in that you are filling up low-Earth orbit with all these doggone things that have no control. However, that's brought about the necessity to find ways to control them. We now have people who are working

on what we call "micro-thrusters." By putting a couple of thrusters on a CubeSat, you can at least orient it and then start it back down towards the atmosphere so it can disintegrate. We couldn't do that before and really want to be able to control them a little bit better.

When CubeSats started going, they really caught on. I give Ames the credit for being the pain in the butt, to be quite honest. Pete Worden used to be out there [as Center Director], and Pete really believed in commercial stuff and they [NASA Ames] became the NASA gurus for CubeSats.

When you talk about international relations, we have a program now that took us years to put in place called the International Intern Program. If a country wants to invest the money and send a student to the U.S., we'll place them for several weeks or months at a NASA center and have them work alongside a NASA engineer or a scientist and allow study here in the United States. Then they go back to their native country and apply what they learn. Turned out initially, Ames was the only center that would open up to that, and it's just because Ames did that kind of stuff. They were incredible at it.

People at Ames were really good with CubeSats and they knew that you could teach anybody to build a CubeSat. In fact, we now have an elementary school here in Arlington [Virginia]—I think it's St. Thomas More [Cathedral] School. It's a Catholic school that actually built a CubeSat and launched it. It was deployed from the International Space Station late last year. They became the first non-commercial, non-national entity to put a satellite in space. And it was elementary age school kids, and they did it on their own.

But 12 of the first international interns came from Jordan, so when I visited Jordan last summer, I had an opportunity to meet with King Abdullah and the Crown Prince, who is a student at MIT [Massachusetts Institute of Technology]; he made the Crown Prince responsible for the

CubeSat program in Jordan, as well as developing entrepreneurs, since his son is at MIT, where they spin entrepreneurs out. So he figured that the Crown Prince can come back and help establish a community of entrepreneurs in Jordan. Every one of those students who went to Ames went back to Jordan, and they are now working on a family of CubeSats. So Jordan will be in the CubeSat business before long.

You kill a lot of birds with one stone. We really put a lot of emphasis on finding these types of partnerships, and this came from President Obama. He said during my first year, "I want you to go out and expand the number of nontraditional partners that the U.S. has, because nobody can do it as well as NASA." And so we went out with the stated purpose of bringing onboard more nontraditional partners. By definition, they were countries that were too small to have a space program; either couldn't afford it or didn't have the technical expertise, but given somebody they could partner with, they could be brought into the family of spacefaring nations.

One of my favorites is the UAE [United Arab Emirates]. They are building a Mars orbiting satellite that they want to launch late 2020 to arrive in Martian orbit in 2021, and it's going to fit into the constellation of satellites that today includes Maven, which is ours, that looks at the upper atmosphere, and MOM [Mars Orbiter Mission], which belongs to India, that looks at the lower atmosphere. The Emirati Mars mission will look at the middle atmosphere. Now, I simplify it greatly. It's not that simple, but we will have a constellation of three satellites looking completely across the spectrum of the Martian atmosphere, and again, that's going out and helping to develop nontraditional partners in the space field.

We spent time in Jordan and UAE, and we generally go to Israel. When you talk about science, it's not just space science, and when we went last summer to Niger, the second-poorest country in the world, we were there to stand up a new SERVIR site. This was the fourth one in

the world, and it exploded their interest. Niger also has one of the world's worst literacy rates, but the President and the Prime Minister both recognize the fact that if we get NASA and the U.S. Agency for International Development to come in here and put a major program in like SERVIR, we might be able to talk our kids into going to school. That's their hope. Whether it really works or not remains to be seen, but it is this kind of act where you use science to try to promote the development of intellect in nations that may not be able to do that. That was another thing that President Obama really wanted us to push, and so we were able to do that.

WRIGHT: To better humankind?

BOLDEN: Yes.

WRIGHT: Speaking of Earth and everything around it—Earth Systems Science. These programs contribute greatly to understanding climate change and impacts. I know while you were Administrator, a fleet of these Earth-observing satellites were released.

BOLDEN: Twenty-fourteen [2014] was the Year of Earth.

WRIGHT: Talk about that year, and why NASA is such an important part of understanding what happens on Earth.

BOLDEN: Again, all this was headed by [Earth Science Director Michael H.] Mike Freilich and worked when I got here. It was in his brain. The job of the Administrator is to go out and try to

preach the gospel and get converts to come in and put money in the plate every once in a while. I took that on as my job. Earth is the only planet we know that sustains life today, and it's really important to me—it's my favorite planet.

WRIGHT: Mine, too.

BOLDEN: So I started talking to Mike, even before he became the Director of Earth Science. He was here sort of as the Acting Director. [Former NASA Administrator Michael] Mike Griffin had brought him in as an IPA [intergovernmental personnel act] employee. The very first time I met Mike Freilich, I fell in love with him. The guy is just incredible, and he's so passionate about Earth Science. We convinced him to stay—not go back to Oregon State [University—as the permanent head of Earth Sciences. He started teaching me about Earth science and his ideas, the stuff that he wanted to do.

Early on he said, "We can," when I asked about using the [International] Space Station as a platform for Earth Science. Mike didn't just come out and say no, like most other people had said, "No way. It's worthless. It's in the wrong orbit, it's not high enough, and it's this and that. No. Forget about it. Let's not waste time." Mike Freilich said, "Give me some time. Let me think about it." And so what he did was he went off and started working with the community and asked for ideas. It's amazing what happens when you ask for ideas, a lot. He came up with a number of experiments, a number of instruments that could be built for installation on the International Space Station. The advantage of doing that was you got them into a permanent vantage point looking at Earth. The biggest advantage was cost. You didn't have to pay for a launch vehicle; you didn't have to pay for a bus—the vehicle part that flies the instruments

around—because we were just going to take the instruments and mount them on the International Space Station.

In 2014, I think we launched seven—seven Earth science satellites/experiments in one year. It was the most we had ever launched in a single 12-month period of time, so that's why I call 2014 "the Year of Earth." We had [an instrument] that looked at sea level height; we had something else that was looking at the makeup of the ocean; we had all kinds. It was just incredible to see these click off, one after the other and do exactly what Freilich said they were going to do.

Although Congress and mainly the Republican Party tend not to want to talk about climate change or changing climate and the like, one of the sets of instruments that everybody talks about today who knows about it is CYGNSS [Cyclone Global Navigation Satellite System]. It's a constellation of eight very small satellites all launched together, and then they spread out. They orbit Earth in this pattern that gives us—like every 12 minutes—a look at a storm that's either brewing or in progress. The advantage that it gives us that we never had before is it looks in "color"; it actually has infrared and other ways that allows it to look through the storm, so we can actually look down into a typhoon, into a hurricane, into a storm out over the ocean; and allows you to look at the intensity of the storm from the inside, which we could never do before. You had to fly a doggone C-130 or something like that airplane through the middle of the storm to take data, and then you still came up with a rough answer.

Now, we can send the CYGNSS constellation over a storm, and we end up with these doggone 3D images—like you took a slice from the storm. That's all coming from the CYGNSS constellation. Those things are invaluable in forecasting, but mainly we can forecast the *intensity*, which we weren't able to do before. It's one thing to tell people that you have a hurricane coming. Previously, we were guessing on whether it was going to be a Cat[egory] 1 or a Cat 2, or whatever.

We can be pretty precise now on what category hurricanes are going to be when it makes landfall just by having this one constellation of satellites launched recently. And more and more things like that are coming.

What we have also done in the world of Earth Science is to bring other countries in to play with us, because we didn't do it all. With Japan, I want to say it was probably the first Earth Science satellite that we launched in 2014, and it looks at rainfall. It was GPM, Global Precipitation Measurement observatory. That was a combination of JAXA [Japan Aerospace Exploration Agency] and NASA coming together. We launched it out of Tanegashima [Japan]. The brand-new American Ambassador, Caroline Kennedy [daughter of the late President and Mrs. John F. Kennedy], went all the way to Tanegashima from Tokyo to be on hand for the launch. It was really special for the U.S. Ambassador to Japan, which is a major ambassadorship, to be there. She was a big fan of NASA's, understandably, and any time we invited her to do something, if she could do it, she did. She was absolutely incredible her entire tenure, but to have her be a spokesperson for NASA—and she had the connection where, when she said it, it meant something to people.

She did a symposium over there celebrating her dad's legacy, and talked not only about space, but about peace, and talked about his Rice University speech. She said, "What everybody forgets is the other part of it." She said it was really a two-part speech. He talked about space, going to the Moon, and everybody remembers that. Nobody remembers what he also talked about was world peace, and how we've got to work really hard to get there. At this event, she had two panels, and I participated on one that talked about space. Then Chris Matthews from MSNBC led the other panel, and they talked about peace, and peace building, and peace making, and all that. It was absolutely incredible, and a good time.

WRIGHT: A good experience for you to be a part of that.

BOLDEN: Yes, it was.

WRIGHT: Bringing together information, and the dissemination of it—NASA contributes so much to academic researchers, supporting them in various ways. I think I read where over 10,000 scientists just in the U.S. use the information that—

BOLDEN: I would not doubt it. It's a massive number.

WRIGHT: So I'd like to have you talk for a few minutes about the value of NASA support to the area of research on its contribution for the global environment, but also NASA's involvement in education programs, and how that comes back to help not just environment, but other industries.

BOLDEN: You hit a nerve. Education is an area about which I am passionate. I come from educators, my mom and dad. Of all the things that I thought I would be able to do, that I really wanted to do and have us do very well, we struggled [with the area of education]. And we continue to struggle with education. We just can't get it right, although the impact of what we do is incredible.

We got the present President's budget that zeroes out the education program in NASA. We'll find a way [to provide educational information], because we always do. The directorates will take it over, and they'll run education programs and outreach programs from inside the

directorates, probably. Hopefully. But there are a lot of things that are done that are done in the Education Office that we are going to have to figure out, and boy, how do we make up for it if, in fact, the President's budget goes through and Education is zeroed out.

But it was just a hard nut to crack, to try to get Education to be organized in a business sense, so that there would be no question as to whether money was being wasted, or whether planning was done efficiently, and all this kind of stuff. I don't know what the answer is. Some entities do it a lot better than others. SMD [Science Mission Directorate] does an incredible job, but it was initiated some SMD directors ago, they mandated that every project will spend 1 percent on educational outreach. It just became a part of what they did. Some projects did it well, others did a lousy job, but still, it was in their mind that they had to do it.

Gerst[enmaier] spends a lot of money on education. As you know, the International Space Station is probably the biggest educational outreach tool that we have, because that's the way we get into classrooms around the world, not just here in the United States. Almost every single day of the week, some school kids somewhere in the world are talking with astronauts from aboard the International Space Station, and that's the inspiration we were talking about. It informs, because a lot of kids have no idea that all this is going on, and then they sit there mesmerized by talking to an astronaut in space.

Usually, it's some congressman who didn't know it, either, and we always let them know when we are getting ready to do something, so if they want to go to the school engaged in the event, they can take credit for it. They can be a part of it, like Lamar Smith from Texas, one of our biggest detractors, particularly when it comes to Earth Science. We have done—I want to say during my eight-year term—we did three downlink TV opportunities for him alone in the San Antonio schools. A congressman is usually lucky if they get one. He got three, just because he

asked for them, and we said, "Okay, if the Chairman wants it, we are going to make it happen." So he took credit for it, and they talked about Earth Science, and they talked about everything else, and then he went back and talked about how bad it [NASA's focus on Earth science] was on the Hill.

The opportunity to present STEM education and subjects of a technical nature that kids would not otherwise be exposed to is something very unique to NASA. Earlier I talked about SERVIR; it's a program that we have, where we cooperate with the U.S. Agency for International Development [USAID]. There are only four sites around the world, and they take all the Earth Science data—all the archived Earth Science data for however long NASA has been around, and real-time data from all these orbiting Earth science satellites—and they feed it into these four hubs around the world. From there, it goes out into that particular region. The one we opened up in Niger came from overwhelming demand from the nations of West Africa when they found out that we had a SERVIR site in Nairobi, Kenya, that was servicing all of East Africa and Southern Africa. It was helping them with crop planning, water resources management, disaster management and disaster relief, and they wanted some of it. And so they just started coming to us. We finally got together with USAID because they do the major funding. We just provide the data. So we decided, okay—it usually takes a little bit longer than this to develop this program, but this is so important, we want to do it presto.

And so we opened up a SERVIR site in Niamey, Niger. The year before we had opened up the third one in Bangkok, Thailand, and that services the entirety of the Mekong Region, all the way from China around to Thailand and areas over there. Then there is one in the Himalayas, in Kathmandu, Nepal, that serves nine nations that are around the Himalayan mountain range. Their biggest challenge is water. With all those mountains and all that snow, they can't control water in

terms of getting drinking water or when the floods come, keeping it from wiping out everything in its path. The focus of that particular SERVIR site is actually glaciers and water. There, our partner is the Chinese. Two years ago, when they had the last earthquake in Kathmandu, ironically and just by chance—by fortunate chance—we had a team of NASA and Chinese scientists in Kathmandu on the mountain studying glaciers at the time when the earthquake occurred. Because that area where they were was okay, they were able to get real-time data to people who were coming in to do rescue and recovery, provide them imagery and everything else they needed so they would know where to go, what villages that had been destroyed—places that it would have probably taken them weeks to get in there by foot, but we were providing spaceborne imagery so they could know where to go and where to send food, and needed supplies.

WRIGHT: Amazing. That's a neat story. I'm glad you shared that with us.

BOLDEN: My favorite ever is still—have you seen the movie *33*? That's the Chilean miner rescue [in 2010], and you know that very well, coming from JSC [Johnson Space Center]. To me, that is an absolutely incredible story.

I was sitting in this office, sitting at my desk, and Tina Palacious was here with me then. She stuck her head in and said, "Sir, there is a gentleman here who says he is the Ambassador from Chile, and he needs to talk to you." I said, "Shucks—if he is an ambassador, send him in." He came in and he introduced himself, and he said, "We need your help." I said, "Mr. Ambassador, what can we do for Chile?" He said, "Yesterday, we had a collapse in a mine, and we have 33 miners trapped belowground, several thousand feet, and if NASA doesn't help us, they are going to die." I said, "Mr. Ambassador, we don't do mines." I said, "What do you have in mind?" He

said, "I don't know." He said, "But I know if NASA gets involved, then we'll figure something out."

WRIGHT: Wow. What a vote of confidence.

BOLDEN: That's when we went to Ralph Roe down at Langley [Research Center]. At the time he was running NESC [NASA Engineering and Safety Center]. From JSC, they put a little team together, went down to Chile, and surveyed the situation. They started working with Vickie Kloeris [Manager International Space Station Food System at JSC] and the folks in the food lab there. They had concluded that if we can't feed them, they are going to die, because this is not going to happen in a week. It could take a month to get them out of there. The lab took a break from planning food to go to the International Space Station and figured out how to get food to 33 miners that were 3,000 feet below the ground. They knew that there was an air hole, and they knew the size of the hole, so they designed these little capsules as something to put food in, and they did that.

Then there was a father and son team over in Afghanistan who I think were working for the State Department, or they may have been working for DoD [Department of Defense], but they were drilling water wells over in Afghanistan to support the troops there, and they heard about the miners. They were from somewhere out in west Texas, and the father said, "Okay, let's pack up and go." I forgot who he went to, but he got in touch with who was in charge and said, "My son and I want to come help." They knew that there wasn't a way to make a hole big enough to get a person up and out. So they went back.

We had an engineer who had come from the nuclear navy and the Chief Engineer with the Chileans was a Navy veteran, and so the two of them started thinking about submarines, and capsules, and all related areas. We ended up putting this team together, and you know the story, because you talked to them [for the NASA Oral History Project]. But they did it.

WRIGHT: It's really amazing. Yes, they did.

BOLDEN: Those are among the things that just gets your heart going boom, boom, boom, and you feel really good about it, so—

WRIGHT: We find that [NASA] "meatball" everywhere, don't we?

BOLDEN: Yes.

WRIGHT: Yes. But we didn't find it on an asteroid yet. Do you want to talk about ARM [Asteroid Redirect Mission]?

BOLDEN: Let's talk about ARM. And ARM is another story. ARM came about, as you may know, when the President shocked us with his pronouncement that we were going to put humans on Mars in the 2030s, and in the meantime, we were going to put humans on an asteroid in 2025.

Although we were surprised, it didn't sound too bad. We said, "Oh, what the heck. We don't know how, but we can probably do that." And then somebody said, "But you do know that asteroids are farther away than Mars?" I went, "Oooh." They said, "Well, yes. The main asteroid

belt is between Mars and Jupiter," or something like that, and I went, "Oh, geez. How are we going to walk this one back?" That was one.

The other thing was Orion. Although we were really happy that he talked about Orion, he referred to Orion as an emergency crew rescue vehicle, and we went, "Oh, that is bad, bad, bad." Because one of the things that we did was we promised industry that we would not compete with them, that we would not make Orion capable of going to Station, because that would just kill them. They wouldn't be able to market it [their commercial crew vehicles]. So we said, "Boy, we have got two things that we have got to walk back that the President said." Orion was a lot easier.

We started looking at how do we get to an asteroid before you get to Mars? How do you plan this thing? Then somebody who was working with UNCOPUOS [United Nations Office of the Committee on the Peaceful Uses of Outer Space] and some other places said, "Well, we have this challenge: we are trying to answer the call to find out how you protect the planet. If we think about somehow either intercepting an asteroid and putting people on it, sort of like *Armageddon* or something like that, who knows? We might be able to do something." And OSTP, folk over there, the technology people, they had something totally they wanted to do—they are really into crowdsourcing and stuff like that, so they wanted to go out to the whole world and come up with a way to put humans on an asteroid. We said, "That's not the way you want to do that."

But we came up with the Asteroid Grand Challenge, and that was a way to get all of humanity involved in anything about asteroids. Identification. We were falling way short of identifying smaller asteroids that could, if they impacted Earth, cause significant damage. They weren't civilization-destroying ones. We had a mandate from Congress from, like, 20 years ago, and we had met the mandate for big asteroids: those that are 1,000 meters across and bigger. We were not doing very well on the little ones. But the good thing was President Obama started

pouring money into our Planetary Science program specifically to study asteroids and to identify those Earth-threatening asteroids. I think over time, he actually quintupled the amount of money that we were getting for asteroid studies and the like.

That also gave us an opportunity to go out to other countries that had telescopes and see who could help in that regard. A big hole: there are no observatories in Africa, and there is a lack of a lot of observatories in the Southern Hemisphere. So Jim Green and his folk went out, and they went all over the world. They are all over the world trying to find people who are willing to turn their telescopes to help us look for asteroids.

Involving the public became sort of a part of the Asteroid Grand Challenge also. We held forums just to educate people about near-Earth objects. I don't know whether you heard about this or not, but down in North Carolina was a seventh grade teacher, who had been working with her class on asteroids and near-Earth objects. She had been explaining to them how asteroids are identified and named, how planets are named, and all that. So she gave them a bunch of data from wherever this place is that we identify asteroids, and they spent the school year combing through the data, and they came up with seven objects that they felt met the criteria to be classified as asteroids and submitted it to the American Geophysical Union [AGU].

The AGU looked at these seven, and they said, "I'll be damned." They said, "These are asteroids." So we had a group of seventh grade kids from Raleigh, North Carolina, who did a one-year project with their teacher and got credit for naming seven asteroids, identifying and naming seven asteroids.[1] That was one of the things that came out of the Asteroid Grand Challenge, and those were the kinds of things you wanted to do.

[1] https://www.wral.com/story/raleigh-seventh-graders-mapping-asteroids-saving-the-world-/13497251/

That's what OSTP was more interested in, those kinds of things. They could care less about putting a person on an asteroid, but we had been challenged by the President to do it. So as we started thinking about it, we said, "If we could get to an asteroid that's coming toward Earth, and find one of sufficient size that it would be meaningful, we probably could capture it and divert it toward the Moon [away from Earth to be captured by the Moon's gravitational pull]. Then, once we get the asteroid into lunar orbit, we can fly astronauts to rendezvous and we can put them on the asteroids. It's not what the President probably intended, and it's a real stretch, but we can at least say we have put humans on an asteroid." Boy, selling that to the President's office—and the President, actually. I remember the last meeting we had over there with Dr. Holdren and the President, he said, "Well, at least make sure the asteroid is bigger than my damn sofa." Or "the rock," as he referred to it.

That's kind of how the Asteroid Redirect Mission came about, but it wasn't to save the planet. It never was intended to do that, and we tried to make it very clear. It was to inform whoever was going to come along and decide that they could save the planet. What we wanted to be able to demonstrate was that physics works, and vector mechanics works, and that if you put a spacecraft with something that's orbiting the sun and you push against it long enough, you are going to change its orbit ever so slightly. And if you are talking about something that's inbound to Earth, you have only got to change it by a couple of arcseconds and it misses Earth. That was the theory. And we said, "Shucks, if we do it and it works really well, we might be able to get it close enough to the Moon that it gets drawn into lunar orbit, and now we can really go study it."

And so that was the basic foundation of ARM. I still think it's a great mission to fly. It got a lot of our partners excited, particularly Italy, because Professor [Roberto] Battiston, who is the president of the Italian Space Agency, is a university professor. He said his students went

crazy when we announced we were going to Mars and when we talked about the Asteroid Redirect Mission. Some of the partners had things that they wanted to develop and test as a part of it. I mention there is a project called DART [Double Asteroid Redirect Test] planned and conducted by the Johns Hopkins University Applied Physics Laboratory [APL] in conjunction with the European Space Agency Hera Mission. I am not really familiar with the details of either missions, but I think what they are going to do is they are going to use a ballistic projectile or something from a satellite and actually shoot it at an asteroid, and then measure its movement. Essentially, if you see it shake or do something, then it kind of demonstrates what we were hoping to be able to demonstrate with the ARM. I think it'll come back—we have to save the planet one of these days, or we've got to enable people to do it.

WRIGHT: Sure. We'll have to stay tuned for more later. Let's talk about aeronautics, because you said there were some really interesting things happening in that area, and I know as a pilot, they must be dear to your heart.

BOLDEN: Well, aero was tough, but it's the foundation of NASA. We got started because of Sputnik, but they didn't just start from scratch. What President [Dwight] Eisenhower and others said was, "Okay, let's take this organization that we already have that's talking about flying supersonic. Let's take that organization that really focused on getting America back in the game in aeronautics after the Europeans took it over and let's turn it to working also on space. We have to beat the Soviets, so let's do that. That's what this new organization is going to do, and we are going to call it the National Aeronautics and Space Administration."

So that's how NASA came into being. But over time, because of the race against the Soviets and other things that happened, the aeronautics funding just started taking a slow decline. By the time I came in with the Obama administration, our Aeronautics budget was really, really meager. The thing that concerned me the most—inside an already meager budget was the fact that hypersonics is a specific area of aeronautics that the only people who do fundamental hypersonic research is NASA. We are the repository for fundamental hypersonic research, and then we take what we develop and we give it to DoD, mainly, and to universities, and then they take it and they develop operational tests, they develop weapons systems; they develop any other kinds of stuff that's going to go at these incredibly fast speeds. When I came in, I think NASA's budget for hypersonics in a $500 million budget was—I want to say it was $100 million. And by the time we got to the middle of my sixth year, we were down to $5 million.

That was the kind of hit that NASA had—and it was out of OMB. OMB had just whittled away at it. I won't say they didn't think it was important, hypersonics was, but they are so stovepiped over there, and the people in NASA Aeronautics didn't really know very much about the state of operational hypersonic utilization. They just knew from talking to their DoD friends that DoD is really looking at hypersonics, that's some really important stuff. The belief expressed by OMB was, okay, if DoD needs it [hypersonics data] they will pay for it, they should just go to NASA and say, "Okay, we need this data." As if we are going to keep wind tunnels running and keep people working waiting for DoD to come and say, "Okay, here is some money. Go do this."

Through Dr. Holdren, we were able to get representatives from DoD, NASA and DARPA together, and we finally reached an agreement where Congress would put $25 million into the NASA budget strictly for hypersonics. That got us back on the road. We are losing our shorts to

other countries. That was also really important. If we haven't already, we were about to no longer be the leaders in hypersonics, which is really bad from a national security standpoint.

Another thing that we were able to do was, when I first came in I had asked Jaiwon [Shin, Associate Administrator for Aeronautics], "Jaiwon, if I went out and asked people in industry what good does NASA do, what would they tell me? Would they even know that we have an Aeronautics program?" He said, "They would tell you that we are valuable, but that we don't do enough." He said, "Because we do the best we can do, but we don't have enough money to do the kind of stuff we used to do." So I asked, "What can we do about it?" He said, "Well, it would help if industry went to Congress and did like the science communities do and told them how important aeronautics is." I said, "Okay. How do we do that?"

It took several years to get there, but he set off with his folk in ARMD [Aeronautics Research Mission Directorate] at NASA HQ and our aeronautics researchers at the NASA centers, and they decided that they were going to completely revamp the NASA Aeronautics Strategic Plan, and they did. They went out and held focus groups, all over the country. They came back and they said, "There are six emerging thrust areas in aeronautics that nobody is really working on, but the nation needs. Industry needs it, and nobody has the money to put into it, or really wants to make the investment right now." They were things like unmanned aerial systems, integrating them into the National Air Transportation System; supersonic flight vehicles that could fly over ground at supersonic speed that are prohibited by law right now because of the sonic boom. Our guys believe that you can actually design an aircraft that will muffle the supersonic boom, and so you can actually get data to give to the FAA [Federal Aviation Administration], demonstrate that this can be done, and they will change the rule, and they will say you can fly supersonic—at least these speeds—over ground. The 2014 ARMD Strategic Plan allows us to move out and go away from

the standard airplane shape that we have today. We call it a "hybrid wing-body." And then all-electric airplanes, trying to find energy savings for airplanes.

We set out to convince people that NASA should be allowed to start building five X-planes. We hadn't built an X-plane in decades. So we started working, again, with OSTP and other people over in the White House, and they liked the idea. It still proved hard getting OMB to fund it, but they liked the idea. Then we started working with the Congress, and that required going to the other side of the aisle, mainly, because they were controlling the budget, and it just so happened that most of the congressmen who represented areas like Edwards [Air Force Base] and Armstrong, Glenn, and Langley [Research Centers], they were all Republicans.

Also, they were all Republicans who had some background with aviation, like Congressman [Steve] Knight from near Edwards Air Force Base [California]. His dad was a NASA test pilot, so he was passionate about it. We had a congressman from down by Langley who had been a military pilot, had a father who had been at Langley as a researcher, and so he was passionate about it. Kevin McCarthy, the leader in the House, his district is right at Edwards Air Force Base, so he is passionate about it. We were able to get the Chairman of the Budget Committee at that time to be a champion. And then Frank [R.] Wolf [Virginia], when we started out.

We got Congress to start just adding funds, bit by bit, a little bit more. They wouldn't go as far as the President wanted to go, but they started gradually adding money into the Aeronautics budget, until we got to the point where this past year, he had allowed us to put in $63 billion over 10 years. The President's budget never got through because the Congress didn't even look at it, but it was like $6.3 billion extra for Aeronautics every year, and that was unbelievable, because their budget was, like, $700 million. So he was going to put a significant plus-up into Aeronautics

to allow us to do these five X-planes. And Congress liked it, but—and they had it in a budget, but the budget never got passed, and so it kind of went away.

Where we are now is that Congress still supports it. We have got enough money in the omnibus budget that was passed and signed by President Trump to support, I think, four of the five X-planes, so they are going on. The X-57 Maxwell, the all-electric airplane with the 14 engines, that should fly next year, actually, because out at Mojave, they build a lot of experimental airplanes, and they are working on Maxwell for us. Lockheed Martin won the contract to do a prototype of the what we call "low-boom supersonic demonstrator [X-59 QueSST (Quiet Supersonic Technology)]," so they are working on that. Boeing dominantly—and a little bit of Lockheed—is working on what's called a "hybrid wing-body airplane [X-48B BWB (Blended Wing Body)]," so that's the new design of an airplane. Then we have a lot of people working on unmanned aerial systems. Plus, the FAA is actually funding six UAS test sites around the country, so we didn't have to spend the money to do it, to help figure out how you integrate unmanned aerial systems—UAVs, drones—into the National Air Transportation System. So Aeronautics is not back where it ought to be, or where we would ideally like for it to be, but it's in a resurgent mode now.

For the AIAA [American Institute of Aeronautics and Astronautics] Aviation 2015, that was in Los Angeles, I had them put together for me a speech that challenged the aeronautics industry to go to the Hill. Because it was illegal for me to do that, I did it in a way without saying, "Lobby." But, I said, "If you all believe in this stuff, you need to let people know it." I said, "I don't have any problem out of the science community. I get more help from the science community—in fact, I get help I don't want, because they go to the Hill and come up with all kinds of crazy ideas that we have to figure out how to fund."

I said, "There is no reason that the Boeings and the Lockheeds and the little bitty aeronautics companies couldn't do the same thing, and tell them, 'This is really important.' And if you think it's important, then you need to become vocal about it." It kind of caused an uproar.

There is an organization called AIA, the Aerospace Industries Association, and it's the major aircraft manufacturers, the people that make aircraft parts, like radios and all types of related stuff. They became champions to help us with it. We rolled out the Aeronautics Strategic Plan at [Reagan] National Airport [Washington, DC] and AIA helped us to get it. We went in the main concourse, and the Airport Authority just blocked off the end where you go downstairs. We had that whole concourse, and a podium, and flags, and models. I gave a short talk about new aviation horizons, which was going to be the X-planes and NASA's new Strategic Plan. Then David Melcher, who was the CEO of AIA, came out. Just before I started I had asked David if he wanted to say a few words. I said, "You don't have to, but it would really be helpful." He said, "Well, I'd love to." And he came out, and man, he gave a rah-rah speech—people just flocked around, and he talked about the critical importance of staying first in the world, the work that NASA was doing, the real importance of this initiative and other kinds of stuff. And I went, "Holy geez."

I think the biggest thing was it just took getting out there and trying to gin up support from your stakeholders, and all that goes with it. That's what the guy or girl sitting in this [Administrator's] office does. And then when Dava [Newman, Deputy Administrator] came [May 2015], whoo, boy. That was like magic.

WRIGHT: Want to talk about her for a few minutes?

BOLDEN: I can talk about Dava forever.

WRIGHT: What an asset she was to NASA—

BOLDEN: She was. The only thing I—well, at first I was never asked about a Deputy. In fact, I asked if I could pick my Deputy, and they said no. I said, "Why not?" They said, "Because it's already been determined." I said, "Yes, but suppose I can't work with them?" They said, "You will work with them." I said, "Okay, if that's what you say." But after Lori [Garver] left, we went a year or so with no Deputy; they just couldn't find anybody. For the life of me, after the fact, I don't know why I didn't say, "I want Dava Newman from MIT." Because somehow, they found her, and boy, when she came down, we took her over to the Hill, and walked her around [to Congressional members], and everybody fell in love with her, because first of all she's smart and she is enthusiastic and bubbly, she loves science and engineering, and she is passionate about aeronautics.

So Dava came in and really became a champion for advancement of aeronautics in NASA, and so that was a big burden lifted. I didn't have to do it all by myself. She went around the world talking about it, and she had the background to do it; she didn't have to make it up. She knew it.

WRIGHT: Yes, that does come in handy. One of the things that you talked about started while here was a Space Technology Mission Directorate [STMD].

BOLDEN: Yes.

WRIGHT: I know you talked a little about the CubeSats, but put it all together for us here, and explain that directorate.

BOLDEN: Remember I told you the President was passionate about technology and technology development. So, that was one of the things that came down to us through OSTP that said, "Okay, the President meant it. He is serious about technology and technology development, and he is serious about NASA taking the lead, and you guys need to get it started." So we went, "Oh. Okay. We have been down this road before." We used to have Code R, and that was a disaster. That was aeronautics and technology development, and I was around for a bit of it, but it just didn't work out.

So we started talking about, okay, how do we do this? How do we promote technology development? A lot of it is done in what we called the Space Operations Mission Directorate [SOMD] that was changed to HEO, Human Exploration and Operations. Then, we had ESMD, Exploration Systems Mission Development [ESMD]. As we started talking about deep space exploration, we were starting to stumble all over ourselves. What you had was a bunch of dreamers in ESMD who really didn't do any kind of operational stuff, and really big ideas, and you had the operational guys out here in SOMD with Gerst, who were launching spacecraft and operating an international space station, and you were going to need both of them to get you to Mars, or wherever you were going.

Plus, you had two pots of money, and it started becoming difficult to get the two of them to say, "Okay, we'll put our money together," because that wasn't about to happen. So I said, "Okay, we can take care of that. We are going to dissolve both organizations, and we are going to

create a new one, and we are going to call it the Human Exploration and Operations Mission Directorate. And so they came together, so that took care of one thing.

And HEO, SOMD had had a small office that did advanced systems: AES, Advanced Exploration Systems. They were down at JSC for the most part, but some up here at Headquarters, and kind of spread out around the Agency, and they were doing little nickel-dime stuff—as much money as Bill Gerstenmaier could put into it—looking at things that were going to be needed if we were going to do deep space exploration—a lot of the things that weren't existent in Constellation, because Constellation was sucking up all the money. But we said, "Okay, that's good, but we really need a directorate that's going to look across the NASA portfolio. We don't want it just looking at Human Spaceflight. We want it looking at Aeronautics, we want it looking at Science, we want it to look at Human Spaceflight, and eventually, we want them to look at IT, because we are way behind the world in terms of information technology. So if we can get a group that will look across the NASA portfolio and just start pushing wild and crazy ideas, that's what we want. We want them to not be afraid to fail. I don't care if they fail sometimes—not all the time—but they ought to be the incubator for new ideas."

So the first thing I did was I brought [Robert D.] Bobby Braun up from Georgia Tech [Georgia Institute of Technology]. He was a professor in the department of aeronautical engineering at Georgia Tech and an old NASA hand. He had been in the Mars program; he had been an EDL—Entry, Descent, and Landing—team member for some of the earlier Mars missions. He looked like a little kid, by the way, so that's why I had a hard time believing all his years of experience. Has a farm—or had a farm in Georgia; he is in Colorado now. He and his wife and his three kids had a farm on the outskirts of Atlanta, and he was happy being a professor and farmer.

But he came up here when I said to him, "Bobby, if you can come up for a year"—and I think we managed to keep him up here for two years. He was on an IPA. It didn't take him very long after he started working. He worked very well with guys out of OSTP, and kind of kept them tamped down, because every idea they came up with, he probably had already thought about it and had a way to do it if he could just get money. And I had promised him with, "Bobby, if you come up, I'll make you one promise. You won't have to carry a tin cup around DC looking for money." Because the President had said, "I want this," and he had put $1 billion in his first budget for technology development, and that was going to be what we were going to use to stand up a directorate. Of his $1 billion request to Congress, we got zero. They zeroed it out, because it was an Obama initiative for one thing, and that made it a non-starter. They just didn't understand. They knew that we were doing a little stuff—we were doing some dabbling over in HEO, so they were happy with that.

After Bobby's first year, he said, "I can't do all this. I am doing what you want me to do as the Chief Technologist, but you really need to have a directorate that is focused on doing this stuff down in the weeds. The Chief Technologist should be your counselor, your advisor, on all things technology, just like you have a Chief Scientist." That was Waleed Abdalati at the time, who was incredible. Waleed did the same thing: he looked across the whole portfolio—Aeronautics, Human Spaceflight, Science—and said, "We are missing the boat here. This is science also. It may not seem like it, but we need to get people to start looking at this. And if we are talking about going to deep space, especially if we are talking about going to Mars, we are going to have to eventually get the Human Spaceflight guys and the Robotics guys to start talking to each other, because they can't do it by themselves. They are going to have to work together."

So I said, "Okay, Bobby. Go ahead. Start putting this doggone organization together." And he did. For almost the rest of his time here, he served as both the Chief Technologist and the first Director of the Space Technology Mission Directorate. He did all the writing of the bulletins and everything; got them sent up to GSA [General Services Administration], got it approved; sent it over to OMB, OSTP, to the Hill. Everybody had questions; everybody had things they wanted to add. But we got it through. That was the beginning of STMD. The last thing Bobby did was he brought in [Michael] Mike Gazarik to work as the head of STMD, while Bobby did the Chief Technologist job. Then Bobby left.

A lot of growing pains with STMD were because they had no money. We took little pockets of money from HEO, and little pockets of money from Science. SMD didn't mind funding them, because they were really producing stuff that could be used by SMD, whether it was sensors or optical things that had never been done before, the atomic clock. They started looking at deceleration devices for Entry, Descent, and Landing for Mars. Everybody realized their value, but nobody wanted to give them too much money, so we had to get money out of Congress. It was almost as bad—it was as bad as getting money for Commercial Crew. Gradually, the Congress started putting small amounts of money into STMD.

Then we brought [Stephen] Steve Jurczyk to HQ. He became the Center Director at Langley [Research Center] after I moved Lesa [B. Roe] here. When I stole Lesa from Langley, and I told Langley I wasn't ever going to bother them again. I think Jurczyk was there for a year, and I said, "Okay, I need you at Headquarters. Can you come help?" So he came up and took over STMD, and it just [imitates sound of an explosion], it just went after that. And he was able—because he was so good with the Hill, and with OMB—he was able to get funding. We still don't

get as much as we needed, to be quite honest, but it served the purpose we wanted, which was to be an incubator.

Steve came in one day and sat down, and he must have been reading my mind, because he said, "I have one thing that's bothering me." I said, "Okay, tell me what's bothering you first, and then I'm going to tell you what's bothering me." What was bothering me was they weren't—nothing failed. Everything they did was working, and that's not why we stood up that group. They were doing easy stuff." He said, "I am concerned that everything is working; that we are not really advancing technology. We are not doing anything new. We are not doing anything risky." And I said, "Okay. How do we fix that?"

He went down to talk to Lauren Leo [Chief Human Capital Officer], and Lauren came up with this catchy phrase called, "fail early, fail smart." She was thinking about it with reference to how you do things with human capital, with personnel management and from that aspect. We kind of adopted that across the Agency; but it helped Steve Jurczyk's guys recognize the fact that it is okay, we need to do wild and crazy things and need to be wild and crazy enough that if we are going to have trouble, we have the trouble early on, so that once we find out what the problems are, we can mature them, and we get into something.

The first big failure they had was something that was really being funded partially by them and HEO, and it was a project that was a methane-powered lander being worked down at JSC. It was a little prototype called "Morpheus." Jon [B.] Olansen was the Project Manager, and Jon and I had worked together before. So Jon was the Morpheus Project Manager, and he started briefing me, and I really liked Morpheus, but they came in and they said, "Look, there is one thing you need to know. This is really—I mean, this is truly a start-up. This is a rank amateur operation here. What we are doing is we are taking interns and we are taking fresh outs [from college] who

are coming into each center, and we are making this an all-star team of brand-new engineers from every center. This is a single-string system, which means there is no redundancy in this thing, so if one part fails, that's it." I said, "I got it," and said, "Sounds good to me."

So they worked for a couple of years, flew a lot of the tethered flights, and were having all kinds of success. Then they decided, "Okay, it's now time to go down to KSC and we are going to do a free flight." And so you all know how this story worked out. They went down there, and *Aviation Week* was there, the *New York Times*, the *Washington Post*. This was just a little prototype, but because it was going to be a lander to go to the Moon, everybody was interested in it. It lifted off and went [imitates sound of an explosion]. And it burned to a crisp. The world was watching, and so as soon as that happened, I picked up the phone and I called Jon. I said, "Jon, do me a favor. Get out there with your team and tell them that's okay." I said, "That's okay. You all told me what to expect, we knew this could happen; it's no big deal. But now we need to dust ourselves off, figure out what went wrong so we can go fly." And he went out and told them that.

They figured out what went wrong, and it was very similar to what had almost caused a catastrophe on STS-1, when we got this big acoustic wave that went down into the flame trench. It bounced back up and struck the vehicle and bent one of the RCS [Reaction Control System] struts up in the forward RCS pod. If it had broken the strut, we'd have lost Columbia right there on the launchpad. What we had done was we had forgotten about the power of sound and acoustic energy. That's when the water sausages developed, where we put this little—I don't know what they were—nylon or something little half-bags stretched across the flame trench, and we filled them with water and ethylene glycol alcohol, and all they needed to do was just survive long

enough to keep the sound from bouncing back up and hitting the vehicle. They did it, because when everything cleared, then they just burned up the bags, and everything was okay.

It turned out that Morpheus had been launching from a flat launch site, launch pad; it had no trench or anything, but it had a rocket engine. Every time it ignited, it just [imitates sound of an explosion], just shook the vehicle, and it did that hundreds of times, every time it launched. The attitude control system finally just shook one time too many, and it just [imitates sound of mechanical failure] died, and it [imitates sound of an explosive crash] crashed. And they said, "Oh! How could we have missed that lesson?" They went back and started putting attenuators or trenches or something in there. So we had to go back and re-learn a lesson that we didn't know for STS-1 but learned for STS-2 and subsequent Shuttle launches.

That was STMD, and it's doing okay. They still don't get enough money.

WRIGHT: Yes. Well, I think we are at our time to get you to your next appointment. I wanted to close up, if we could, with several things, but mostly about the leadership skills and the qualities that you used, like dealing with the contradictions from Congress. During your time here, they would tell you to do things but not give you enough money to do them. One of your quotes from meeting with them was, "You make it incredibly challenging when you tell us to do something and you don't fund it." What type of action plan or strategic movement did you come up with to be successful?

BOLDEN: My first plan of action was to look at the people who were here when I came—and you may or may not know this—I didn't change anybody out. When I first came in, I looked across the board. I looked at the center directors, I looked at the AAs [Associate Administrators], I looked

at the first levels in the centers in terms of leadership, and I said, "Okay, you've got to have a really strong leadership team, and so if I need to change anybody—

I had been here with Dan Goldin. In fact, his first full day in office when Dan became the NASA Administrator was the day I landed on my third Space Shuttle mission, and he was there. He came in the White Room, and I was laying on a gurney. We [the crew] had agreed that we would not walk off the orbiter because we had done a lot of medical science experiments on the mission, and so we let them gurney us off and take us right to the lab to start taking data. So I am laying there, and this guy is leaning in, telling me: "I want you to come to NASA Headquarters to work for me," and I went, "Who the F are you?" I am trying to think of who—George [W.S. Abbey] was there, and George said, "Oooh!" He said, "Charlie, this is Dan Goldin, the new Administrator." And I went, "Oops." I said, "Well, it was nice being an astronaut."

I said, "I am sorry, Mr. Goldin, but you know, I am a little tired." He said "Oh, not a problem. I just want you to come up and work for me at Headquarters." I told George later, I said, "He is out of his mind. I don't want to go to Headquarters. I have never been there, and I don't want to go." George said, "Well, think about it. At least come and meet the guy, and have dinner with him, and then think about it." And I came up here, and I was incredibly impressed with him. Did you ever meet him?

WRIGHT: Yes.

BOLDEN: So you know what he was like. He was a visionary, with zero people skills. I mean, like zero. And therein lay the weakness. I don't consider myself to be a visionary at all, and my people skills aren't superb, but the one thing that my mom and dad instilled in me was the

importance of treating people right, and trying to build teams, because nobody does anything by themselves.

So for me, I had the experience of watching an administrator getting rid of a lot of guys and bringing in new people and seeing it just go horribly wrong for Dan, because he brought people in because he wanted it to look good. You know, he wanted diversity here at Headquarters, and so he wanted a black person, and a female, and everything else. The talent part, that was not something that he emphasized. Just the team of people here with him initially just didn't work. Mike Griffin came in that first group. He was Code X, which was experimental systems. I think Mike lasted about two months or something like that; he said, "I am out of here." He went back and ran In-Q-Tel or something.

It was important to me and I wanted to do it right when I arrived as Administrator, so I kept the leadership team in place. From the very first time I got together with them, I tried to tell them what I wanted to do, I told them what the President wanted us to do—at least, the way I understood it—and I told them that I wanted them to remember one of the things I had said in my hearing, and that was that I was never going to bring anything in that I didn't think could be done. It might be hard, it might seem impossible, but if the team said we could do it, it was going to be something we could really do. I said it had to be sustainable, which meant it had to survive over multiple Congresses and multiple administrations, because NASA never does anything that gets done in one term of anything. And I said it has to be affordable, which means we have got to live within the budget. I said, "If we can do that, then we are going to be okay." I said, "If you tell people it's going to cost them something and then it just goes off the page, forget about people ever trusting you to do anything." That was sort of my Marine Corps heritage coming out. It said, "Always tell the truth." One thing my mom and dad used to say all the time, they said, "You don't

ever have to remember what you said tomorrow if you tell the truth. Then you just say the same thing tomorrow, and you just tell them again."

That was what I told them the very first time, and I said, "That's going to be the key to our success, is telling people what we think the nation should be doing. Make sure that even if we think it's almost impossible, that there has to be at least a pretty good chance that, with some good stuff, we can make this work. Then we have to be able to carry it through a long time and be able to figure out a budget and better live by it."

Then I met JWST. That's why I say I learned a lot from JWST, because there I was not being able to live up to tenant number three, "affordable," because it busted the budget probably before it even came off the drawing board. And somebody knew it, but they figured, "It's too important, and they'll never not add it up." The other thing they found out—at least, they suspected—was every time it was going to get a plus-up, Northrop Grumann knew it before we did, and so the price kept going up. That's sort of the way that industry works. If they know that there is some money out there to take, they'll take it. That's just the way it has worked.

That was the first thing, I was honest with the leadership team and my philosophy, as always, I told them, "Look, I'm a participatory leader. I'm going to probably drive you apeshit, excuse my French, because it takes me a while to make a decision, because I want to hear from everybody in the room. I may know what I want to do, or I may think I know what I want to do, and I may understand everything that you all tell me, but I want to hear from everybody whether they agree with what the majority says or not. And then once we hear from everybody, then I'll give you my answer. But once we do that, then I want everybody to press, because the decision is made. We are not going to do the standard NASA way [which is] the "decision" means the

beginning of the discussion. You guys are going to help me make these decisions, and then we are going to live by them." And so we did that.

And then we brought in Jeri Buchholz to take over Human Capital Management; she preceded Lauren Leo. Jeri was like magic. She had been at the [U.S.] Nuclear Regulatory Commission, and it had been the number one place to work in the federal government. I didn't know that. I didn't know anything about the partnership for Public Service when I came here, but I learned about it pretty quick. So when she came over here, she had a reputation of being number one. She came in and sat down with me; she said, "Look, I don't have a lot of corner on the market on anything," she said, "but I do know one thing. You have to tell people every single day that they are doing good stuff. And also you've got to tell them that you value what they do. If you do that, we got a start. We are least halfway down the road. But" she said, "every single day, you as the leader have to let people know how important the stuff that we do is." And so I said, "Oh, shoot—that's easy for me. I can do that—I'm a Marine."

So that kind of started it. Then we ended up being the best place to work in the federal government and never looked back. But it was because of that spirit that actually was introduced and taught and instilled in me by Jeri. And then Lauren Leo came in and she was even more magic. Having people like Robert, and Dava when she came, and Bill Gerstenmaier and others—I was letting everybody know, "Look, I am the eternal optimist, so I believe we can do anything. You have got to understand that. I am also very naïve. I like it that way; not everybody is proud of being naïve, but I am. I like it that way. So surprise me, do whatever you want to do, but we can really do good stuff if we all continue to pull together."

When Robert came in, Robert was the one that used to always talk to me about, "Let me tell you what they are talking about in the colonies," meaning down at the centers. And I'd say,

"Okay. I am listening, Robert." He said, "You know, they are the last ones to find out anything. Congress knows, people in the White House know what we are thinking about, but employees don't know. They don't have a clue. They get it from the newspaper or they get it from somewhere else. So we have got to find a way to make them feel like they are a part of the team and let them know about things early enough so that they feel they are a part of the process, to include the decision-making." And we said, "Okay, we are going to do that."

Now, believe it or not, we had to battle OMB again, because OMB is very secretive, and they like the idea that they make the determination on money and other kinds of things. So they have a policy that you can't go to the Hill. You can't talk to Congress about things you would like to do until the President has decided that that's okay to do that. And my argument, which I never was able to win them over on, was if that's the tact we take, we are never going to get anything that the President wants done. Congress needs to know what it is that the President wants done so some of them can champion programs for him. I said, "I never really paid that much attention to Congress, but I can vaguely remember growing up and having members of Congress who came in and presented a bill that came from the President, and they were the sponsor." I said, "We are fighting an uphill battle if every time we take something over to the Hill, it's coming from the President, and there is no coordination with the Congress. We are just swimming upstream." And that point I was never able to get across, and so that was one of the downsides of my participation in the Obama administration.

But in spite of that, we tried to find ways to let the workforce know what was going on. The union was a part of the workforce, and although it's relatively small in NASA, the good thing was that the White House—"the White House," that's a building— the President's office, they catered to the unions, which was fine, but they came out with a policy that said, "You should find

ways, to the greatest extent possible, to make sure that the union is involved at every stage in the decision-making process." And so over here, we started a Labor-Management Forum, which I said, "I am not chairing it. I am not even going to be involved. It's going to be the deputy's, and whatever the deputy says, that's it. There is no appeal to the decision of the Labor-Management Forum. You guys are in this together, and so don't bring it to the Administrator, because that's for the deputy." They said, "We are not sure we like that," but I said, "Take it or leave it." And that's the way we did stuff.

Then—although, again, OMB didn't particularly care for it, but—when we started working budget issues, we brought in the union representative. It was generally Lee Stone, which was problematic, because Lee was a really hard guy to get along with for everybody. I learned later he was going through this battle with the center director out at Ames [Research Center] and I could understand that. So when the director left, believe it or not, Lee Stone became a person that was not that bad to work with, because the battle back home was done, and he didn't have to yell and scream at people all the time.

But we involved the union almost from the very beginning in every budget cycle, in every major decision, so they had a bite at the apple. What we told them was, "Look, since you now are up here with the senior management, senior leadership, you don't get multiple bites at the apple. If you don't like the decision, I am not going to allow you to then go back down and 'play union' and come in." That didn't sit well with them, and every once in a while, they tried to say, "Okay, we are going to go to the big union." And they did it a couple of times, and we were able to hold them off because we said, we could document where they had participated in the decision-making process.

So that was the other thing that Robert brought to HQ—keep the workforce informed of what was going on so that they knew about it, and give them bad news as well as good news, or give them news that you think is going to turn bad before they hear it from somewhere else. Those were just some of the things we tried to do. Yes.

WRIGHT: You had some not-so-fun times when you had to face that workforce and tell that information that they just didn't want to hear.

BOLDEN: Well, it was like when it was decided, yes, we are going to phase out of Shuttle, and we are going to cancel Constellation. Houston became a hard place to go for a couple of years, and [my wife] Jackie just wouldn't go with me anymore. She moved up here the Christmas of my first year; before then she had been living in Houston but things hadn't started yet. Then we got our first budget—my first budget, which was the one that talked about termination of Constellation, and phasing out the Shuttle, and all that other stuff. Jackie was in Houston when those rumors were starting to go out, and she said, "I'm going back with you, because you need help." She was right. And so she came back. We kept our house in Houston for almost three years, we had a house-sitter. We would go back periodically, and every time we went back, it got a little harder, it got a little rougher, and—

WRIGHT: Became less home, didn't it?

BOLDEN: Yes, it did. It became a lot less home very quick, and we got cursed out by about everybody. Congresswoman [Anna] Eschoo from California called me an idiot, when we told her

we were not going to spend $45 million to resurface Hangar One [Moffett Field], but that we were going to enter into a long-term contract with somebody to take over the airfield and run it, and they would do all that. She was vehemently opposed to that and did an op-ed or something in the [San Jose] *Mercury News*. It said, "The NASA Administrator is an idiot." But things worked out in the end, so, yes.

WRIGHT: I'm going back to where we started: that your tenure began with a vision to invest in the long view. You were told to have investments in science and technology innovation so it would stimulate enhanced job growth, to develop new opportunities for industry. If you use that list to rate some of the accomplishments of the Agency, how do you think the last seven-plus years went? Do you feel like you advanced those areas as well?

BOLDEN: Oh, I do. I think we did very well. We are on course, on track, to get humans to Mars in the 2030s, which is what we said. Commercial Cargo has proven itself; Commercial Crew is coming along. If you go down to the Cape [Canaveral, Florida] and you look at the vehicles, and you look at the testing that's going on, and when I talk to the Commercial Crew cadre, to Suni [Sunita Williams] and everybody else down there in the Astronaut Office, they are confident that they are going to have good vehicles to fly in. Generally, they don't make stuff up since they are going to be the ones to fly them.

The accomplishments in science are probably the ones that are mind-boggling, because of what we have done and discovered—much of it is stuff that nobody ever dreamed. When you talk about the exoplanets, when you talk about a lot of the Earth science that we have done to help us understand the planet better and to try to provide data to the decision makers so they can do things

to help clean up the environment, I think it's invaluable. The work with SERVIR. I am happy all across the board.

I am disappointed that we weren't able to do more in aeronautics. I really had thought—and I still hope—that we could get the budget over $1 billion for Aeronautics, because that's really what they need, and same thing for Space Tech. My hope is that some time during the first Trump administration, I will be able to look at the NASA budget and see $1 billion in Space Technology Mission Directorate and $1 billion in Aero. They can do what they are being asked to do, but it's just so hard trying to make ends meet when you are just—they are like Texas—well, you are from Texas, so you know this: they are like Texas general contractors. You know how they operate? Ask anybody who is in general contracting in Texas: they pay for this job with the next job they are getting ready to do. They never have enough, because they never bid right. Or they don't handle money right or something, but they are always paying for the job that they are working on now with the advance that they got from the next project.

I don't see how they survive. But I know how it feels. Gerstenmaier is magic. I have never seen anybody handle money, handle funds, the way he does. It sounds like a lot of money, but when you look at all the things that HEO has in their portfolio—not a lot of people realize that all of our deep space communications, all the spacecraft communications and navigation, that's all in HEO. We have been told by the General Accounting Office on numerous occasions that, "Man, you guys have got to do something about funding for SCaN. It's going to collapse." And infrastructure—the center directors, when you look at what Ellen [Ochoa] has done at JSC after the cafeteria wall fell in Building Three and didn't kill anybody—we were lucky. Then, figure out ways to how to shore it up because we've put this off. They shouldn't have to do that. But it's just, that's the way we do it.

WRIGHT: Well, before we close, are there other topics that you can bring to mind, or do you have anything on your list?

BOLDEN: You hit everything I wanted to hit, and I thought.

WRIGHT: We just kind of talked a little about Mars, but I didn't know if there was anything you wanted to add. The fact that it keeps—

BOLDEN: Boy, I'll tell you, I am excited about Curiosity's follow-on, Mars 2020, because that's going to be the first one that'll actually have an experiment that's going to take—it's going to make something from the CO_2 in the Martian atmosphere. It's going to extract oxygen from the CO_2 so they'll have oxygen to go in propellant for an ascent vehicle. If they find methane, as we still hope they will—we haven't done it yet, but if they do, then that'll be the fuel. If they don't, then they'll use hydrogen that comes out of the water. So we'll get the fuel and the oxidizer for the ascent vehicle from right—it'll be like *The Martian*, since *The Martian* was really like what we are planning to do, to be quite honest.

We have learned a lot from what Curiosity has done. It's not quite as robust as we had hoped it would be; all those treads have a hard time, but it's doing great stuff. It's really given us a lot of new and exciting ideas about how you approach putting humans on the planet. The one thing that it's done that has been invaluable is giving us a complete chart or a complete data source of radiation from Earth to Mars and then operating on Mars day-in and day-out, because it's a constant, constant flow of radiation data, but it's made us feel a lot more confident that we can

survive the Martian environment. It would take something—galactic cosmic rays or bad things, and there is always a chance, but they are also rare things. We feel pretty comfortable about humans living on Mars and I happen to believe we are going underground because that's the safest place to live. We'll be like the cavemen. Rather than trying to live up on the surface and build habitats that shield, you just send a fleet of robots up there in the late 2020s and let them start digging, and build a habitat, and move humans in when we land there the first time. So I would not be at all surprised if that's what we do.

There is actually a private citizen who has a hobby with limestone caves, and he is out in New Mexico or somewhere like that, who has now constructed a whole series of caves into the limestone. And [James H.] Jim Crocker, who used to be with Lockheed Martin—retired recently—his second passion is caves, his first passion is a cure for cancer, since he lost a child to cancer. But he says the guy has used simulated lunar soil and made a cement—a sealant—that you can actually put around the door of a limestone cave, and you can seal it off so you can pressurize the inside. So it'll be a pressurized compartment where the astronauts can live.

That's a private citizen, and that's going on right now, and there is no NASA funding going into that. People are interested, and people are doing things until they get to the point where they can come in and talk to NASA and say, "Hey, I've got an idea. Would you be willing to partner on this?" Having something like Space Act Agreements has really been a sort of magic for us, because it's allowed us to spend very little money on some really great ideas, as long as people are willing to put in their fair share, because they anticipate that down the road, they'll get their money back. So that's been pretty good.

WRIGHT: And now you have got proven precedents for it, too—

BOLDEN: Yes, exactly.

WRIGHT: —so people aren't afraid to come to NASA to ask that.

BOLDEN: Yes.

WRIGHT: So, you have any advice for the 13th Administrator who might be coming sometime soon?

BOLDEN: It would be the same advice that I would have offered to the President if anybody had asked, and it was, "Come in and observe for a while. Kind of fold your arms and take credit for everything that's going to happen in your first two years as the NASA Administrator, because a lot of really exciting stuff is going to happen." So the 13th Administrator will oversee the launch of JWST, and the launch of Commercial Crew, and probably some really important finding on Station from a pharmaceutical perspective. We may be into human trials on the salmonella vaccine, so that person will be able to take credit for that. Hopefully, we will see the first couple of X-planes flying.

So there is a lot that the 13th Administrator will have an opportunity to see before they have even finished the first half of their term if they are patient and don't decide they want to change the world, because as you all know, it takes a long time to recover when you decide, "Okay, we are going to stop and start all over again."

That would be my advice. My un-bold advice.

WRIGHT: It sounds like you left a good foundation for them to walk into, so—

BOLDEN: I left them good people, and so they are the foundation, to be quite honest. So, yes.

WRIGHT: Well, we'll end it with that sentence, then.

BOLDEN: All right.

WRIGHT: Thank you again, sir.

BOLDEN: No, thank you. Thanks for coming up and doing this, and good luck with the other 11 interviews. So, whoo!

[End of interview]