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ORAL HISTORY TRANSCRIPT

KATHRYN L. LUEDERS
INTERVIEWED BY REBECCA HACKLER
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HACKLER: Today is April 17, 2013. This oral history interview is being conducted with Kathy Lueders at the NASA Johnson Space Center in Houston, Texas for the Commercial Crew & Cargo Program Office History Project. Interviewer is Rebecca Hackler, assisted by Rebecca Wright.

Ms. Lueders is the former Manager of NASA's International Space Station [ISS] Program Transportation Integration Office, and recently moved to her new role as the Deputy Program Manager for the Commercial Crew Program. To begin today, can you share a little bit about your background and how you started with the ISS Program?

LUEDERS: I have an engineering degree, and I started out at the NASA White Sands Test Facility [Las Cruces, New Mexico] coming out of school. I got my B.S. [Bachelor of Science] in Industrial Engineering, and was hired into NASA at that point. When I went to White Sands—I'm going all the way back—at the time the [Space] Shuttle was just beginning to bring in-house a lot of the work that had been done at different vendors. The NSLD, the NASA Shuttle Logistics Depot down in Cape Canaveral [Florida], that was processing Shuttle hardware wasn't able to do any of the hypergolic work.

It ended up being an opportune time for me. From a NASA perspective, they were looking for, "Where's the place we can do work on hypergols [hypergolic rocket propellant]?" It

ended up that White Sands was a NASA facility that could do work with hypergols. They had been doing hypergolic engine testing for a while.

As such, White Sands ended up almost like a NASA subcontractor to USA [United Space Alliance] under the Shuttle Program because of the new SFOC [Space Flight Operations Contract] that was developed. So as we were developing this capability to refurbish RCS [Reaction Control System] thrusters and OMS [Orbital Maneuvering System] engines and other components that were in the OMS/RCS propellant systems and pressurization systems—while this work was moving into the contractors, we still were retaining this capability for NASA.

Over time, I was working all these projects that were bringing that work in-house, and I became the White Sands depot manager, working with USA and [The] Boeing [Company] almost as a subcontractor, supporting. So I really had to think at that time about how do you set up these collaborative relationships with these contractors, new relationships with the contractors to support the work that needed to be done. We had to think about how we were not just NASA because of our capability. Obviously our service was an integral part of what USA had to do to deliver the orbiters down to the Cape, so we were a key component of their schedules. NASA having this capability and working the logistics infrastructure—within NASA we had kind of lost that expertise except out at White Sands.

So in the late 90s, when the [International Space] Station was looking around the Agency, at that time I had started to apply for depot certification under the Space Station Program for the White Sands Test Facility. When the Space Station Program folks came out and met me, at that point they realized, here's this unique capability.

I always view White Sands as like a project training ground, because they grow people there in these very dynamic project environments, and then you've gotten this great experience

to run a project. Nuts and bolts, run budget, schedule, work with program offices, do this whole thing. I was, at that point, plucked to go and develop the post-production support contractors, which is really the contract for sustaining logistics support for the International Space Station.

That was also a key area where setting up those contracts helped me. The budget expertise and nuts and bolts, hardware, engineering—how do you bring in capabilities, how do you set up that infrastructure. That helped me set up the logistics infrastructure for the Space Station Program heading into a sustaining phase. They had worked development for most of the 90s, and starting in 2000 was really when we were starting to look at setting up refurbishment contracts and buying hardware and how do you set up the next sustaining phase for the program.

As part of that, I had worked a lot with the Deputy Program Manager [for the Space Shuttle Program] at the time, Jay [H.] Greene, with my Shuttle experience on what are all the processes that you need to work to help set up and take care of hardware as it's going through the system. We set up the System Problem Review Teams [SPRTs] for Station, and that was a brand new activity. We set up how we process, how the engineering teams give direction to the contractors that are working on the hardware, and how this interaction between the contractors and the NASA side helps get hardware through the system quickly so we're not holding them up, but yet we're understanding how they're working with their hardware. That gave me a better understanding of how to set up processes where you're working with your contractors very quickly.

After doing the logistics job for a while, then based on that experience with the SPRTs, they had me become the ISS Vehicle Systems Integration Manager. Setting up the support systems to help support the logistics activity ended up giving me expertise over in the system

area, so they had me then over the Station processes for all the system teams and engineering support for the system teams.

At that time, I was picked for a leadership development program. I went up and worked in [NASA] Headquarters [Washington, DC] for a year, and actually did two major activities. One, I worked in the Office of Legislative Affairs as the Space Operations Mission Directorate [SOMD] rep [representative] to the House Science and Senate Commerce Committees. Then I understood a lot of the policy approaches that were emerging at the time—it was the 2005 timeframe—about Alternate Access to Space [Station], looking for commercial alternatives to transportation. Shuttle retirement was looming, and I worked a lot of that language and the relationships on the [Capitol] Hill side.

My second project—Mr. [William H. "Bill"] Gerstenmaier had put me on an acquisitions strategy team that looked at the acquisition strategies across ESMD [Exploration Systems Missions Directorate] and SOMD at the time. We laid out an acquisition map, and that gave me a lot of insight on different kinds of procurement strategies, and how they were linking up between ESMD and SOMD. Then I came back to JSC.

After you're at Headquarters for a while, sometimes you're happy to be back working technical issues. I was really happy about going to jump into this. At the time, Bob [Robert D.] Cabana was deputy JSC director. He decided to give me a new opportunity, which was to be the SEB [Source Evaluation Board] chair for the facilities contract. JSC was going through a restructuring of all their Center contracts. For six months, I got to work with a really great team of folks, able to really learn the procurement side of things and develop what it takes to put out an RFP [Request for Proposal].

We saw it through the process, getting ready to release RFP. I was going to go work that whole process, and then the Station program pulled me off the SEB and asked me to lead their COTS [Commercial Orbital Transportation Systems] ISS integration efforts. So looking back at it, I ended up having all of these key experiences that really helped jumping into that COTS integration job.

My first job was to develop a set of requirements for a commercial provider to come and berth to the Station. I had six weeks to do that because I got the job in mid-October [2006] and the first SpaceX [Space Exploration Technologies Corp.] SRR [System Requirements Review] was December 4th, or something like that. But I think looking back, it's been fortuitous because all those different experiences, and having different places along the way, have lead me to be able to progress into these other functions. That's a long answer. Probably too much.

HACKLER: No, we appreciate having as much information as possible. You mentioned Alternate Access to Station, and we know there was also the ISS Commercial Cargo Services program that was started at [NASA] KSC [Kennedy Space Center, Florida]. When you heard about these ideas to have commercial companies help with ISS resupply, what were your first thoughts and impressions?

LUEDERS: The Commercial Crew and Cargo Program actually was here under Alan [J.] Lindenmoyer. Coming from a Station perspective, I think there was a level of skepticism, just because the Space Station Program had been working [Japan Aerospace Exploration Agency] HTV [H-II Transfer Vehicle] and [European Space Agency] ATV [Automated Transfer Vehicle] for 16 years, from a concept phase, really for a long time working through things.

When I was at Headquarters, I understood the intent of the initial $500 million dollar investment for Commercial Crew and Cargo and some of the initial concepts. There was initial skepticism, but honestly, there was a large group of folks—in fact, Alan and Valin [B. Thorn] came from the Station Program, and the core group of folks that worked that activity from the Station Program were very excited about what options you could do, and what different options industry could come in with. But in 2006, the concept of when we would actually be able to do resupply contracts was very far away from people's—I think people were assuming that we would not probably go out for the contracts right away.

It was interesting, looking back. There was a camp of folks that were just really excited about seeing if they would be able to enable an industry, and then there was a group of folks in Station that had worked these ATV and HTV vehicles for a really long time. One of the key things was bridging those two organizations, I think, from a job perspective. One of the first things I had to do was understand what we had learned from ATV and HTV and put them in our requirements, taking those lessons learned and making sure that we applied them with how we were setting up all of our interface requirements.

There have been a couple rounds of Alternate Access to Space. They had had an industry day in the summer of 2005, and had looked at different options and what was out there for folks do. It kind of started the concept of going out with the RFI [Request for Information], and then the [COTS] Announcement for the Space Act Agreements. The idea that we were absolutely going to depend on this activity—it took us a couple years of many different strategy sessions for us to get there.

HACKLER: When the COTS program started, was that viewed by the ISS office as something that would become a primary means of resupply or as more of a backup option?

LUEDERS: Honestly, the Station Program was just really trying to figure it out. I would say it was very difficult. I think it was more of a backup option initially, but 2006 is really when we started the planning for post-Shuttle transportation. I had been on teams in 2004 where we started to say, "What does the Station look like post-Shuttle?" A lot of what Station looked like post-Shuttle with those concepts was a very different, pared-down Station. We were laying in plans where we didn't have return [capabilities], we didn't have powered payload access anymore. It was a very different Station concept.

One of the key things for the Station Program that I did in the early 2007 timeframe, working with Mr. [Michael T.] Suffredini [ISS Program Manager], was to start the discussions with Mr. Gerstenmaier. "We've got to start imagining what Station can be, and what transportation capability we need to invest in," to not have us cutting off opportunities, but to enable opportunities. That was really when we started planning and laying out, "What are our different transportation options?"

At the time we started looking at, "Is there any potential for getting additional HTVs? Is there any potential for getting additional ATVs?" Because of the work I was doing from a COTS integration management perspective, we started assessing the progress of these new vehicles that Alan's shop were investing in to say, "Are these really developing in a way that we think we can potentially do a contract?"

In the fall of 2007, we did an RFI out of SOMD. It was a Headquarters RFI where we looked at what is the potential industry base for a commercial cargo contract, and we actually

had three days of meetings with industry. Based on that, it at least showed us there was enough interest out there that if we put a large value contract out as a carrot, there is a potential that we may be able to jumpstart this new cargo capability.

We started really pulling together the different options and the concepts for the Commercial Resupply Services contract February through fall of 2007, because we were really trying to figure out, "How do we solve this problem?" How do we solve this transportation problem for meeting our needs? We thought if we could go out with a contract, let's just see if industry can meet our needs. Then if not, that was data for us to be able to feed back through the agency and back to the Hill, and be able to work it that way too. It gave us, from a programmatic perspective, a couple options if we went out with the contracts.

HACKLER: The original plan for COTS was to have the companies go through their demonstrations completely before doing the Phase 2 acquisition of services. When you decided to start developing these contracts for resupply, was there any resistance to doing that earlier than the timeline they had originally predicted?

LUEDERS: In March 2007 we had a team that included LSP [Launch Services Program], Ray [Ramon] Lugo [III], Alan Lindenmoyer, and myself, and we looked at the original assumptions out of COTS and the timelines that the companies out of COTS had given us for turnaround, because the big issue is lead time. After working with LSP and the industry data that I talked about before, what we ended up finding out is if you wait until you demonstrate to award, then there is this huge transportation gap of about 27 to 30 months, because typically that's the lead time to be able to start the contract.

What really drove the decision—we worked different timelines and options, and there are a couple of charts that we used to go back to the Agency—was data that said we really need to let the contract by December 2008 to have transportation services by December 2010. Based on that lead time, we needed to start in late 2008 for us to have a potential for having cargo services by Shuttle retirement in December 2010.

Honestly, we probably should have done it a little bit earlier, but the reason we waited until December of 2008—if you looked at the COTS demonstration milestones and what had been in their Space Act Agreements—was that the partners were not going to have pretty significant demonstrations done before 2008. That ended up sliding out over time, but looking at the original timelines, what drove the release of the RFP at the time it did was going back and looking at the original COTS assumptions and timelines. After looking at their assumptions, we realized that the timing didn't work, and we would have been without transportation services for two years.

HACKLER: Did you use any of the COTS milestone progress to inform your decision about the CRS [Commercial Resupply Services] contracts?

LUEDERS: No, you can't. So that's the first thing. The contracts are awarded based on their proposals. Obviously, Mr. Gerstenmaier, as a selection official, can look at any kind of data that's out there to give him an assessment of the risks of each of the proposals and the ultimate award, but we're probably getting over into the procurement activity areas.

As somebody that is managing the contracts, I would say we worked hand-in-glove with the COTS program because obviously their progress is lead time for our progress. In fact, we

used to have joint quarterlies together. It was a conscious decision that Alan and I made, to make sure as NASA we're speaking with one voice. Understanding that yes, Alan was managing the demonstration flights, but obviously he recognized that their progress toward those demonstrations was in our critical path. Both of us really understood that we had to work and work strategy together.

The other thing that I think was very key for the both of us was that not only was I the manager of the CRS contracts, but I was also the manager of the ISS integration effort. The group of folks that closed out the ISS integration interface requirements were transitioning into being on the teams that are also managing the contracts. So that knowledge of the vehicles through the integration activity was moving and transitioning into the teams that were working and technically managing the flights.

We were able to leverage off of that work that had already been done, and then just do delta requirement closures for the cargo-related items for the first CRS mission. Because of that, we were able to optimize our resources and the contractors' resources, and then optimize how we were relating with Alan's folks too. It led to a smooth transition.

C3PO [Commercial Crew & Cargo Program Office] and my office—I think a big component of the success of the COTS/CRS model has been because our two offices worked so closely together. They kept their investor role, and we were able to keep that government function and the contract. Honestly, it worked very very nicely. There were a lot of times that we would sometimes play bad cop, good cop with each other. Alan would go, "I push them this far. On the Space Act, I can't really get them to do it." I'd say, "Okay, well I'm going to really push for this milestone." It was very collaborative between Alan and me. Honestly, it was a great, great collaboration between us.

HACKLER: Earlier you mentioned your work putting together the Interface Requirements Documents [IRDs]. How did you work with the companies to make sure that they met all the requirements, and how did that impact the development of their vehicles?

LUEDERS: I think that the key thing is I viewed the companies as a partner in developing the requirements. Remember when I said I had six weeks? I had six weeks to pull these together. I was very blessed with the fact that, coming into it, I had a draft set of requirements. The draft set of requirements went out for the SpaceX SRR. I went to the SRR and said, "I know that this isn't a perfect set of requirements. Really the way I want to hone these requirements is negotiate them with you, because I think that's going to help me get to a better set of requirements."

Through the January, February, March timeframe, SpaceX really invested and sent really smart people to come in and negotiate those requirements with us. "Why are you doing this?" It forced our engineering folks to really think about, "Well, why are we doing this," and help them out. Then when we got done with SpaceX, RpK [Rocketplane Kistler] came in, and we spent two and a half months, again, working that same set of requirements and honing them. Then they came in and asked the hard questions, "Why are you doing this, why does your verification statement say that?" Our first revision of the document came out in July of that year.

From the very beginning, from a commercial standpoint I realized that the key thing for them—the only requirements document that those providers had was SSP [Space Station Program] 50808 [ISS Interface Requirements Document]. It had been an Agency decision. In the fall of 2006 Suffredini decided, "We're going to get them one document. All the requirements are going to be in one place." We're not going to do this where you're referencing

all these books. We're just going to give them one set, and we're going to try to have as much of this stuff as possible in this one document.

People kind of fuss about the 50808 sometimes not being a perfect Tier I, II document. It's a kind of—excuse the term—a bastardized document because it's this goofy—it's like a CM [Configuration Management] manager's nightmare in some cases because it's got high level things, but it's also got these very specific, lower level, what people call PIDS [Prime Item Development Specifications].

The nice thing was, from a contractor's perspective they don't really care. "Okay, you give me one book." It's really only NASA people that have a Level 1, Level 2. Working it through with those two companies—honestly, coming out of that summer, we probably got a book that, for the most part, was 90 percent negotiated. Not only for the requirement, but for how we were going to verify the requirement, and what kind of data was required to close out the requirement. There were some areas where it took them some maturity, but there were other areas where we really got to understand between the two of us what it took to close out and verify the requirements.

That did help give them a better understanding of how much work it was going to take for them to close out the requirements in certain areas. We really hashed out integrated testing requirements. It took us a little bit longer to work out our prox ops [proximity operations] requirements, like how we work the two vehicles working together, but with most of those it was because the contractors' engineering and analysis hadn't really caught up to be able to even ask the right questions. "How many Monte Carlo runs did you have to do?" Some of these negotiations need to happen when you almost have a Critical Design [Review] work through.

We finished up and got the initial baseline version of the document out that summer of 2007, then Orbital [Sciences Corporation] was awarded a contract the next year, so guess what? We went through another round of negotiations. Honestly, that experience was a really, really good experience. We went through another round of it just recently, working with the Commercial Crew Program. With the Commercial Crew Program, you get a new set of eyes. They come in and go, "Really, why are you doing that? Why are you doing this?"

It's a pain to keep a book where everybody is looking at this set of requirements and trying to make sure that it doesn't drive them in a certain way, but it's also in some ways a really good thing because it really makes the Station Program have to justify why that requirement is there, and why it's worded a certain way. We've gone back and forth on doing separate books and tailoring, and we've kind of resisted that because you really want to have a single book that's for commercial vehicles to come to Station, so that anybody that's a commercial vehicle can come to Station.

We just went through an exercise and added docking capability, because before we just had berthing capability. That enabled us to be able to use that same book for commercial crew, and that same book for cargo vehicles that may want to move to docking. It allows this still to be the same, so no commercial company can come in and say, "Oh, you gave me a whole different set of requirements." It's the same book, and it's out there for anybody. If there's a new kind of concept, if a SpaceX in the future wanted to come up totally separate of any commercial crew program, they could meet 50808 and be able to come up and dock or berth to Station. It's actually a very powerful concept.

Everybody always comes in and says, "Oh, it's a lot of requirements." It is, but so far SpaceX and Orbital have been able to meet it, and the commercial crew providers have been able

to at least meet that language in a way that they've been able to understand it and close out the requirements to it. It keeps getting tested across different contractors, but so far all of the new commercial crew providers have adopted Rev [Revision] D, the latest Rev on 50808, onto their recent round of CPC [Certification Product Contracts].

Typically these IRDs—they are really just used in the development, and then maybe you go do some ATPs [Acceptance Test Procedures]. Nobody's really looking at that IRD anymore. But this IRD has been used over and over for the last five or six years. It's been a huge accomplishment for the Station team, I think.

HACKLER: Did you ever encounter any issues with companies trying to retain control of their proprietary data when you were working with them on the requirements?

LUEDERS: It definitely is a big struggle. At the very beginning, we struggled with when you're looking at a change to a requirement—when you ask multiple companies for their comments, in some cases it can be very revealing. When you're dealing with commercial companies, we had to totally change our mindset of how we managed data. It was a huge change for the Space Station Program.

We learned a lot from Alan, because Alan's shop really understood that the most. As we started collecting data, we had to learn that lesson. You have to care for their data, and make sure that they don't lose that because the one thing they have is their data, right? It's their competitive advantage. There were definitely a few times that data got sent inadvertently —thank goodness it's only happened twice—but proprietary data and how data is handled have been huge issues, just things that you have to deal with.

You see the same thing over here under commercial crew. Wherever you're in these environments where your agreements mean that they still hold their IP [intellectual property], then you have to have a way to protect it. LSP has got it down to a fine art, too. They have a very similar type of contract, and they probably have more controls on the data than we do in some cases, but it's the same kind of thing where you're using a service. We learned a lot from them about how you really have to keep the key aspects of the data regarding the service under control.

On the other hand, we've been very tough with the contractors about where there are products that are really tied to the Station mission, like mission integration products. Those are not marked as proprietary because those are very important documents that, as a Station program, we need to be able to share amongst all our partners for us to be able to do our planning.

We did have to work with the contractors about a strategy that if there's something that's design data, you need to start learning how to separate it out. Don't give me a single document that's got a lot of your mission integration products and these very technical aspects of your mission in one document. You're going to have to develop strategies to separate that, so that we have a way to give the needed documentation to do mission integration with the Station. For the parts of the integration process that are very technical in nature, we just keep that to a core set of folks that we limit the data access to.

HACKLER: You mentioned sharing the data with the partners. How is it different working with the commercial companies as opposed to the International Partners, or even doing integration with Shuttle?

LUEDERS: I actually think in a lot of ways there are similarities. The experience that we had on ATV and HTV—I honestly don't think we could have done commercial resupply as well without those experiences. There were several aspects that, as a program, we had to develop new ways of thinking to accommodate the IPs [International Partners] that really paved the way for our commercial approach.

I was Vehicle Systems Integration Manager when we were planning to fly the first ATV. We had to sit down and define just a basic thing like COFR [Certification of Flight Readiness]. "What does COFR mean? What does it mean when you ask a system manager, 'How is this vehicle safe to come up to Station?' What level of deep diving are they going to be able to do when it's an International Partner vehicle?" I had multiple meetings with the Chief Engineer's Office about what am I asking engineering or the safety organizations or MOD [Mission Operations Directorate] to do when they're coming in and saying this vehicle is okay.

We had to establish boundaries. We had to say, "You're only reviewing it up to this level." At this point, the program is taking the risk. Or we're looking at other areas that the partner's COFR at that point is coming in to support. It's their responsibility to provide that part of it. Your job is to do enough, where you're assessing what they've given us, but not necessarily that you've done the work. We had to do that for ATV, we did that for HTV. Our system teams got very good at getting a sense of where are the places that you really need to deep dive, and where are the places that we know how to look at data. We know how to assess.

We had the same kind of discussion with the [ISS] Node 2 [Harmony] and [Node] 3 [Tranquility] that were built by [Thales] Alenia [Space]. They weren't Boeing modules, so we had to figure out the same kind of thing. Where do you check to make sure that yes, the data that

they're giving you makes sense, but you're not redoing the Italians' work. All of that caused the Station Program and the organizations supporting it and doing integration tasks to really look at things in a different way, in a different model.

Talking to the engineers—when you've had to work an Italian module, and then you worked the Cupola [observatory module], which was German engineers and different countries, and then you're going to work with the JAXA [Japan Aerospace Exploration Agency] guys—if you then work with a commercial company, at least they speak English.

Those models really, really helped the discussion as I was sitting down with our system managers and the different parts of the program to say, "Okay, now we're trying to do a commercial model, and here's our goal. We're going to put together a set of requirements where we're only going to assure safety in the Keep Out [Sphere] zone and docking." All those people that started with the Shuttle model in 1998—after 10 years of new countries, new vehicles, new interfaces—by the time you get to 2008, they're pretty agile.

It was very refreshing to have people come in, and the requirements have been bounced against an HTV, have been bounced against an ATV. All that experience really enabled us to be able to have the discussion with the commercial companies in a way that we said, "Here's our baseline, we've done it lots of different ways. How do you want to do it?" and have them propose. But we're also very sure about where do we have to engage, what was our minimum. You struggle in other programs with, "What is the minimum? And when you've integrated a couple vehicles, you start realizing what a "minimum amount of work may be." We got smarter with SpaceX. We'll get smarter with Orbital.

That's why it was important that I kept the ISS integration of the commercial crew vehicles under ON [Transportation Integration Office], so that within that organization that had

been working integration of these other vehicles, we were bringing in the lessons learned for the commercial crew vehicles coming in. One of the key folks that had been working ISS integration, [T.] Quan Le, is now in charge of the Commercial Crew Integration group within the Transportation Integration Office. Quan worked all the HTV integration activities and he's now sharing those experiences with crew. You've got other folks that had worked Orbital and SpaceX, supporting those activities and working those activities.

HACKLER: When you're trying to coordinate all these different resupply options, how do you address any challenges that may come up when, for example, there are milestone slips or a flight is delayed or scrubbed?

LUEDERS: I think it's hard. I think one of the real challenges we had when we let the contract in 2008—we knew that this was pretty risky, and we understood it was a risk going into it. A lot of our strategies were based on, "This is a hard job for a company." It's a fixed-price contract. We're asking them to do something that NASA hadn't done in a long time: design and build a brand new launch vehicle and spacecraft in five years, with multiple vehicles.

In December of 2008 when we let the contract, we knew if we didn't manage it in a way that we were recognizing the technical risk, and if we were going to be beating them up—that was not what was going to deliver successful cargo providers. In the management of the contract, a lot of what we did was talk about balance, because we understood the technical and financial risk these companies were taking to develop new capabilities for us, for a lot less money overall than what typical NASA programs had been up to that point.

When you look at it, SpaceX ended up designing and delivering their first couple vehicles under the COTS program for $600 to$700 million dollars. On the CRS program, we've probably spent a little bit over a billion dollars, and we had four vehicles on flow at SpaceX and four vehicles on flow at Orbital. That's not very much money overall when you think about all of that.

I would say when we were putting out the contract, we were very thoughtful about when we anchored our need. We had put December 2010 in there for a specific reason, but we also put a lot of things in the contract that enabled the contractor to baseline their dates as we progressed through the strategy. The contract itself is set up where each time we ATP, we both agree on what the mission profile is. There are a lot of ways in the contract where, as we both agree, we can move dates.

We did it specifically. One, because we knew that they were going to have to, and second, the Station changes so much, we did not want to be in a situation where you have a [Space Shuttle] *Challenger* [STS 51-L accident] or a *Columbia* [STS-107 accident] and we're down, and we don't have this ability to be able to move dates without getting into launch penalty situations. We spent a lot of time up front already planning for the fact that we knew we were going to have to be moving dates around. We allowed it within the contract, as long as both of us agreed, and where it was one person's move versus the other, that we both negotiate whatever level of consideration we thought was practical at the time.

The contract was awarded in 2008. In March of 2009, we did our contract kickoffs. Over the next three or four months, we did ATP of the first missions with both contractors. We planned a gradual ATP of when the missions were going to go, and in a lot of cases it was conscious—I'll give you an example. For SpaceX, the first mission out, SpX-1 [CRS-1], we said

it's going to be very challenging for them to get just a pressurized cargo mission up, so we consciously did not fly unpressurized cargo on that mission.

At the time, we weren't even planning cargo on the [COTS] demonstration mission. It was just going up and berthing. We then ended up, under the CRS contract, buying cargo capability on both demo [demonstration] flights [SpaceX and Orbital]. But originally there wasn't any of that. We knew with that next mission we're going to have to take this in steps. SpX-2 [CRS-2] we did our first unpressurized. Honestly, if they would have flown when they first said they were going to, we would have been in trouble because it took us two and a half years to figure out how to do robotic extraction from their mission.

It goes back to this concept of '"balance." We set it up as a fixed-price contract, but both sides understood the technical challenges that both sides had to overcome for us to be able to do integrated missions. We consciously said, "We're going to work with the contractors. We're going to monitor their milestones. We're going to work together when they have schedule slips, and we're going to get consideration for those." Because both of us wanted to slip in some cases, the timing enabled us to be able to handle it in a collaborative way.

Because we did it like that, the Station Program over the last year and a half got a considerable amount of additional capability on the missions. Because of how we worked SpX-2 and 3, and timing of those—on SpX-3 we're going to get six powered middeck lockers instead of the two powered middeck lockers, for every mission from that point, which is huge for us because powered science and samples has become the big driver in Station, from a science perspective.

It's kind of interesting—in 2007 when we started this concept, everybody just thought about the amount of upmass. Because we dreamed about what Station could be, and what is the

transportation capability that matches that dream, guess what? Now we can start talking about flying back and returning things, where before it was just, "How are we going to survive on [Russian] Progress [vehicle] flights? We're not going to have human samples, we're not even going to be able to return." Now we have the ability to do National Lab concepts.

The animal enclosure module, that's another change. SpX-4, we're going to be flying mice and rats. That was never, ever dreamed about, that we got return [capability]. What's going to be great about this is, as we're building the commercial crew concepts, the commercial crew concepts mean that you get science return in an hour. Which is critical for any micro-g [gravity] experiments with animals, because if you don't get it turned over and in a lab within the two- to four-hour timeframe, the micro-g effects on the samples go away. Even on other samples, if you can get where experimenters can look at that as close to that micro-g environment as possible, that's how we're maximizing the science.

Guess who does one-hour turnover? Commercial crew vehicles do one-hour turnover. When we were building the commercial crew requirements, we put in our science requirements. We put in powered middeck capability so that, along with returning crew, you can be returning science samples. It's another case where we had to dream about what we want Station transportation to look like, "What do we want to enable from a Station model perspective?"

The key learning thing for me is if all we're worried about is slips, and we're not worried about what does this mean for a healthy contractor, then we're in trouble. Along the way, we've had to understand what is the risk to the contractor, what do we want them to be, and then at the same time, hold them to their performance.

SpaceX flew three times to Station in their first year of operation, and delivered cargo—May 2012, October 2012, March 2013—a brand-new commercial company doing that. I don't

think Shuttle flew three times in their first year. It's phenomenal, it's phenomenal that they did that. But in 2009, if I would have been driving them into the ground with launch slip costs, we wouldn't have been able to have gained the benefit of their expertise.

It's going to be the same kind of thing for commercial crew. We're going to have to understand their technical challenges. We're going to have to understand that we want providers. We're also going to have to understand that development is hard, and we've got to balance them meeting their objectives with the ability for them to stay moving towards the target. The other thing you've always got to balance with a fixed-price contractor is you don't want them to be starving.

We were always very cognizant of having a healthy contractor, having them be challenged and pushing them forward, and making sure that they understand that they're still accountable for providing a service to the government, but you don't want them making the wrong move because when they make the wrong move, then we don't have the capability. So we talk a lot about balance. We'll be talking a lot about balance as we get into commercial crew, because it will be even more important to make sure that they're making the right decisions to not give up safety.

HACKLER: It sounds like it's really exciting to see all that work coming to fruition, and being able to do all these science missions.

LUEDERS: There have been a lot of times we didn't think we were going to get here. It's just phenomenal. I'm just so happy to see there's a rocket on the pad, I don't know how many years I was looking at just pictures. I also realize how very blessed I am because, in five years, I've

been able to see more hardware under my contracts—Amanda [M.] Mitskevich and LSP, obviously they're seeing this—but there's not any place else in the Agency where you are going to go in and see—SpaceX at one time had four capsules all lined up.

They were like, "Hey Kathy, here are your four Dragons." There just isn't anywhere else you can do that. It's phenomenal, it's very rewarding. It's a lot of work, and I'm not saying that it wasn't very nerve racking, but we keep going.

The most fun part of my job is to go into some of these places and see people about your age, Rebecca, working and being excited about this stuff. When I go to SpaceX, I see it all the time. When I'm at Orbital, I would be in meetings with managers and we'd all be old. But the really cool thing is I went to the control center at Wallops [Flight Facility, Virginia], and their test team that was checking out the rocket—I was like, "Here, I finally found you guys!" I knew there were some young people working this program on the Orbital side, it couldn't just be all old guys.

These are people that are learning how to fly rockets, and learning how to fly spacecraft, and they're learning how to go to Station. They're learning about what it takes to do reentry shields and work all these things. When you go and look at all the people that are learning now about what it takes to fly into space—it was funny, talking to the Orbital guys after they got the contract and we were working with them for about seven, eight months—they said, "We just thought this was like a satellite." But guess what, now they know how to do mission integration, they know to do integrated operations. Our MOD guys are like, yes, they can go do an integrated mission.

The SpaceX guys—the first integrated sim [simulation] they did scared us to death, but honestly they did phenomenally. This last mission [CRS-3], their lead flight controller—I think

he's 27 or 28 years old—did a phenomenal job when they were having a problem with their spacecraft. The spacecraft is in an uncontrolled tumble and the SpaceX flight team is just continuing, and they recovered that spacecraft. I think that's not only an achievement for SpaceX, but an achievement for NASA. The SpaceX team really learned from our team. That, to me, is tech [technology] transfer at its ultimate. We're teaching other people how to go into space, and it's just phenomenal.

WRIGHT: You've really hit a lot of good spots. Thank you.

HACKLER: You really have, it's been very informative. Thank you very much.

[End of interview]