NASA JOHNSON SPACE CENTER ORAL HISTORY PROJECT
COMMERCIAL CREW & CARGO PROGRAM OFFICE
ORAL HISTORY TRANSCRIPT

GWYNNE E. SHOTWELL
INTERVIEWED BY REBECCA WRIGHT
HAWTHORNE, CALIFORNIA – 15 JANUARY 2013

WRIGHT: Today is January 15, 2013. This oral history interview is being conducted with Gwynne Shotwell at the Headquarters of the Space Exploration Technologies Corp., or SpaceX, in Hawthorne, California for the NASA Commercial Crew & Cargo Program Office History Project. Interviewer is Rebecca Wright, with Rebecca Hackler. Mrs. Shotwell serves as the president and COO [Chief Operating Officer] of SpaceX, and is responsible for the day-to-day operations including production, launch, sales, mission management, and finance, and for managing all customer and strategic relations to support company growth.

We know you have a very busy schedule, so we are very pleased that you were able to sit down with us this morning. We'd like for you to start by going back before you had this partnership arrangement with NASA, and explain to us why SpaceX was interested in moving into commercial spaceflight, and how your involvement started with the COTS [Commercial Orbital Transportation Services] program.

SHOTWELL: The company was founded in early 2002, really with the sole emphasis goal of providing reliable, low-cost space transportation, and always with a commercial focus. Not that we wouldn't want government customers. We want all customers, but we really wanted to be able to provide this critical service to the nation and to our international friends commercially.

WRIGHT: So for you the sky was really the limit. Whatever you could develop?

SHOTWELL: That's correct. Everything had to fit into the strategy. We didn't want to go off and make copiers, or satellite communication systems. We really wanted to focus, initially, on space transportation systems. The focus on reliability was because Elon [Musk, SpaceX founder and CEO (Chief Executive Officer)] eventually wanted to carry crew to space. Not tourists or joyriders, but really a capability that could facilitate true exploration of space. For that, we think that a combination of robotic missions are necessary, but also human missions.

WRIGHT: You were here only a few years when NASA decided to move into this new way of doing business. How did you first learn of that opportunity?

SHOTWELL: There had been some hints of NASA looking for commercial entities to do interesting things in space. There was a sole-source procurement to Kistler Aerospace that was announced, and through a lot of industry input that procurement was withdrawn.

It was that NASA was looking at a different way to do business in space. I'm assuming from that particular activity that NASA began to figure out how to really leverage commercial industry to do these difficult things. Difficult, but hopefully repetitive things, so that NASA could focus its energy and its emphasis on the much harder things, the deep space missions.

I believe the first official announcement of COTS was in 2005, so we stayed closely tied to the folks who were talking about that. Very closely tied to NASA, to make sure we understood what they were thinking, and how they wanted to develop this procurement, because

we definitely wanted to participate. It looked very well aligned with what we were trying to do, facilitating commercial access to space for the more routine missions.

We received the RFP, the Request for Proposal [COTS Announcement] in January 2006, the company largely shutting down and everybody working on this particular effort. At the time, it was that critical to the company and to our future. We thought it was, and it turned out that it actually was. It was a smart emphasis for us to put into this.

I believe we submitted the proposal in March of 2006, that timeframe. We had been working on the proposal for something on the order of four or five months, and we submitted it. It was a big relief. Development of Falcon 1 [rocket] continued, and we were also working on Falcon 9 at that time as well, or certainly the propulsion systems for Falcon 9. We got back to technical work, as opposed to proposal work, and heard back later in the summer that we were one of the finalists, and it underwent some pretty substantial negotiations. They were fast, but very intense. We've done big deals where we've taken years to negotiate. This I don't recall being years, I recall it being months, but it was quite intense.

I remember two very interesting things. The first was they were very focused on the business. Who would our potential investors be, how much money did Elon have to invest, and what was he willing to invest in this company? What did our business look like at the time. I would say almost a solid 50 percent of the negotiations were about our business. We did a very thorough analysis, so of course we looked great, but I remember that being a huge emphasis.

Then the other, of course, was on the technology. Can this very young, brash company do what they say they were going to do in that proposal? We obviously convinced them that we could do what we said we were going to do, and then we had to work out what is the program really going to look like? NASA understood where we wanted to go, but they had a limited

budget. Not everybody that was a finalist could get the money that they requested. So as opposed to NASA telling SpaceX, "Well, we can't give you this much money, just cut your price"—they didn't give us the target either, so we had to kind of go back and say, "What could we do to still try to accomplish the goals that we were looking at, but for less money?" What did we feel we could do without? We went through a series of discussions with staff to figure out what we felt could be adjusted and still meet the same goal.

It's interesting—some of the things that we removed early on, NASA, as we proceeded down the program, asked us to put back in. Some of those milestones became those augmentation milestones [fiscal year 2011 COTS budget augmentation]. I remember cutting out a lot of qualification testing in exchange for basically running in proto-flight mode. We were basically going to run in a proto-flight mode. We cut out thermal vacuum testing, we cut out a lot of EMI [Electromagnetic Interference] testing, saying, "The first flight could serve as these big system tests."

But as we proceeded and got closer to the flight date, NASA wanted to go back and do things a little bit more traditionally. Never did they go back and say, "Class-A program, let's figure out what we haven't done that we do on all these big programs, and let's go back and redo everything." We kind of picked the testing we wanted to go back and do, instead of having that first flight be our qualification test.

It's interesting that some of the things we cut out came back in the end to the program. Which I think was a nice validation that the discussions that SpaceX and NASA held jointly during those negotiations were important discussions. It was important that we said we would initially want to do those things, but I think it was pretty telling that NASA said, "Let's try to back off from the more traditional way of doing things, and see if we can manage expectations

broadly," and they did for a really long time. But as we got closer to flight, especially as we had been delayed, the pressure really was on to make sure that this flight was successful. We agreed jointly to go in and enhance the program.

WRIGHT: Tell us about the parts of the [Space Act] Agreement that you felt to be very beneficial to your company.

SHOTWELL: I don't think there was anything about that agreement that was not beneficial to both partners. It was an enormous—I always refer to it as a contract, and I know it's not a contract, it's an agreement—but it was an enormous win for us. I'll never forget the day that we found out that we won. All of us—all 80 of us at the time, maybe more—we were down in the lunch room, and Elon was at the front. He was trying to look not happy, but I knew. As part of the announcement Elon and I knew, so he was trying to look unhappy. Then he said we won, and the crowd went crazy. It was $278 million originally, and many, many factors larger than any contract we had received at that time.

It was a great moment, and then the hard work began. We received the award, we signed it in August of 2006, and in September we had a very big milestone. It was the program planning [Project Management Plan] milestone. How were we really going to manage this now that everybody's on board, Congress is on board, and we have our partners lined up? What have we learned to date, and how are we going to execute this really seemingly impossible program? Then we started working really hard, since September of 2006.

WRIGHT: You've accomplished a lot between then and now. What do you feel is the biggest challenge of working through the agreement to make sure that the milestones were met, to get where you are today?

SHOTWELL: The biggest challenge, I think, that we had in the execution of this was convincing NASA, every step of the way, that though we're going to do business very differently, we're going to get it right. Because no one had experience doing this job the way we wanted to do this job. Unfortunately, the industry is frankly, I think, hampered—I've been doing this for 30 years, so I think I can say that—by cost-plus contracts. The incentive on a cost-plus contract is not to minimize cost, it's to maximize effort.

Our philosophy was not minimize effort, but optimize effort. But you still have to get it right. You optimize effort to get it right. It was never optimize effort to keep stringing it along and keep getting paid, because we didn't get paid until we completed a pre-negotiated milestone with 15 or 20 major topics. For each one of those 15 or 20, you had to satisfy the customer. It was a matter of how are we going to get to the endgame in the most optimized fashion, from a time, a level of effort, and an investment perspective?

It didn't go exactly the way we thought it might. We did spend dramatically more than we anticipated we would spend. Originally, it was a $278 million agreement. This was, after all, the negotiations and after we were cutting things out of the program, and we thought we would invest about $105 million. So that total—$278 plus $105, that's not quite $400 million. In the end, we spent about $850 million, and NASA's investment was $396 million. So we spent more.

On the other hand, you can't look back and say that that wasn't all worth it, right? I can't think of a place where we spent money and effort that I would say we shouldn't have done.

There might be a couple of tiny pockets, but I'm certainly not aware of them. We ended up doing the right thing, both for NASA and the stakeholder, as well as for SpaceX, and I think, critically, from my perspective, for the taxpayer in the U.S.

I was really proud of that job, so proud of NASA's program leadership, and program management. It was against all odds for years and years and years, especially as we were as we were delaying and we were late. They hung in there, they stuck by their original philosophies, and never seemed to waiver at all with lots of criticisms flying everywhere. Alan [J.] Lindenmoyer [Commercial Crew and Cargo Program Manager] is such a rock, and so is Bill [William H.] Gerstenmaier [NASA Associate Administrator for Human Exploration and Operations]. I don't think there's ever been a development like this, that the taxpayers pay for, where they've gotten such value. I'm so proud of this whole team.

WRIGHT: Can you give us some examples of what types of expertise and impact the NASA side was able to offer to you as you were developing your spacecraft?

SHOTWELL: There were a number of areas. I would say NASA's biggest contribution was that they certainly let us go on the path that we were going. They would point out where they felt like—even though we're on this very different way of doing business, with this optimization effort ongoing—"We really feel like you need to go do this thing, you really should consider doing this." Aerodynamic testing was one area. NASA came up with some ways where we could get it done in a much different fashion for far less effort, and in the end less money, as opposed to doing wind tunnel testing which can be very expensive.

We developed these little—I call them Dragon bullets. We actually fired these little Dragon capsules with a gun, and they looked at the flow field around the capsule in a much smaller chamber with a very different set of inputs. I think that was a highly valuable test for us. I think we got a lot of support from [NASA] Langley [Research Center, Hampton, Virginia] on that.

NASA Ames [Research Center, Moffett Field, California] was very helpful on the heat shield side. We developed, in partnership with Ames, the PICA-X. It's the heat shield material; PICA stands for Phenolic Impregnated Carbon Ablator. There was one vendor, one supplier of this PICA, and we were quite concerned. That's so not SpaceX-y, to have one supplier for a critical element. If it's connectors, or wire, or metal, it's different. You can have one supplier, because you could go off and find it somewhere else if necessary. But to rely heavily on this material from one supplier, we were very uncomfortable.

We didn't want to base our entire reentry success on one supplier, so we said we're going to build this material ourselves, and it was kind of a public formulation. Ames helped us with it, and they also did a lot of the testing for us. I believe we actually paid them for that. We developed our own PICA. We call it PICA-X, and it outperforms the vendor, the normal supplier of this material. It did better in our jet testing. That was great. And that's a big coup for Ames as well. So now the U.S. has at least two suppliers of this critical heat shield material.

WRIGHT: That's nice, you filled in that gap as well.

SHOTWELL: Yes. Sole-source is never great. The sole-source vendor is going to make some money; they're always going to make some money.

WRIGHT: Or a single point of failure, depending how you look at it.

SHOTWELL: Yes, or they're a single point of failure. So we don't have to have that anymore. I know we did some GNC [Guidance, Navigation, and Control] testing in Huntsville [NASA Marshall Space Flight Center, Alabama], and that was helpful. [NASA] JPL [Jet Propulsion Laboratory, Pasadena, California] was enormously helpful. It's an FFRDC [Federally Funded Research and Development Center], and they were enormously helpful with our LIDAR [Light Detection and Ranging] development. They had been through that process for the Phoenix [Mars] lander. They used a LIDAR to help them guide their landing.

I've got Langley, Ames, Marshall, and JSC—I'm saying that last, but they are by no means last. They were enormously helpful on the program management side with Alan Lindenmoyer. Mike [Michael J.] Horkachuck [NASA COTS Project Executive] has been a steady, constant technical support for SpaceX. Kathy [Kathryn L.] Lueders and Angela [T.] Hart on the ISS [International Space Station] side have been extraordinary as well. Kathy is another one of those rocks where you know she's going crazy inside, but she holds her path and seems to be completely unfazed by the chaos around her.

Things looked pretty chaotic at certain times. Not that we're going to fly in chaos, but there were some crazy times in those five years before the first flight. We flew the first time in less than five years, but getting to ISS took us a little over five, actually almost six. We got to ISS in May of 2012, and we started late 2006. So less than six years.

WRIGHT: Let's talk about the differences of working under the COTS program, but also working with the ISS, with the Interface [Requirements] Document. Making sure that as you were building your spacecraft it was going to meet the visiting vehicle requirements.

SHOTWELL: The program had done a great job, because they actually had a set of requirements. Sometimes they moved around a little bit, which is troublesome, but in general it was a firm set of requirements. They had had ATV [Automated Transfer Vehicle] visits, they had had HTV [H-II transfer vehicle] visits, so they were used to these people coming in, wanting to knock on the door of the ISS.

They had a list of requirements, and we love requirements. I know there's some question about whether you can actually mandate meeting requirements on a Space Act Agreement. We never saw it. We had visiting vehicle requirements, and they weren't going to let us fly if we didn't meet them, so we were going to meet them. It's a little bit stupid, really. We thought they were very clear, and we designed our system to meet them.

The challenge was, how do you show that you meet them before you go knock on the door of the ISS? I think the biggest challenge in the requirements was demonstrating that you meet them, because there are hundreds, if not a thousand or so, requirements. And you want to make sure you demonstrate that you meet them before you fly. There were a lot of years of discussion on how do you demonstrate that you've met them. Not how do you meet them, but how do you prove that you've met them? There was a lot of discussion on that.

WRIGHT: Are there some in your mind, off the top of your head?

SHOTWELL: Software, software quality. I'm a mechanical engineer. You design a gearbox, you put requirements on it. You measure it physically, you measure the torque output; it's easy. It's right there. You see it, you can hold it, you can weigh it. Software is hard from my perspective.

We struggled mightily in getting NASA comfortable with the way we develop software. Very different from the way NASA developed software. First of all we use C++, a very modern coding language. We don't have to leverage legacy coding languages from the '80s or earlier, and the process is very different. I'm not a software person, but apparently the use of C++ allows you to develop software very differently from a kind of a waterfall process, and it was one of the reasons for the final delays to the program.

NASA wanted to make sure that the software was exactly right. We went through another very long, and I'll say painful—it was painful for both NASA and SpaceX—I call it finals week. We wanted to fly, and NASA said, "No, we're going to do another audit." We had just completed two audits, and they said, "You've made way too many changes since your last baseline drop," of our verification events.

They wanted to examine every change to the software. Even though from our perspective, we followed our development plan and said, "There's a sieve that is supposed to highlight the big changes, and the big software changes don't get to go through the sieve without NASA permission." We felt like all the software changes in question that we had made should have gone through the sieve, but NASA was not certain. So we went through every software change whether it was a significant or insignificant change. The number was more than 1,200. We literally brought up each change, looked at the software before, then after the change, and then followed the test method and results for every change. It was over 1,200.

But we got through it, and it was one of the most valuable times that NASA and SpaceX spent together. Actually, I think it was a period of ten days. Started at seven in the morning, finished around midnight. It's a huge effort. I felt bad for the NASA folks, but we got through it, and it really helped cement the relationship. Yes, these guys do things very differently from the way we normally see our contractors do business, but they got it right.

WRIGHT: It's the results that they were looking for.

SHOTWELL: Yes, yes. It's relationship building, too. We've found that relationship building is critical. Range safety is another great example. It happens to be a government entity, but it doesn't have to be. There's this entity that kind of is the guard at the gate, and you need to get to the point where they trust what you're saying because they can't check every little thing. You just physically can't check every little thing. They have to trust that you are doing the right thing, that you understand what the requirements are.

In the range safety case, you understand how to make a system safe, and if we can't write everything down or do a test to demonstrate everything, that we understand philosophically what's necessary. We hold it in our hearts that it's critically important that we don't hurt anybody, and don't hurt an asset on the range either, and then you can make progress and move forward. So range safety, ISS safety, COTS program—a lot of it was about those relationships.

WRIGHT: Then you also had the opportunity to have relationships with other federal agencies like the FAA [Federal Aviation Administration], is that correct?

SHOTWELL: That's correct. We had had relationships with the FAA prior because we're a commercial launch entity, and so we have to get a license from the FAA. The relationship with the FAA had a couple of little bumps along an otherwise smooth path, but in general we have a great relationship with the FAA, certainly now. Again, it's developed over years. We've been working with the FAA, I believe, since 2003.

WRIGHT: I think we'd be remiss if we didn't capture what you thought about your two very successful milestones. One, your first demo [demonstration] flight, and then of course berthing with the Station. Can you give us an idea of what it was like here, and your feelings? Maybe even before, were you concerned?

SHOTWELL: Oh, yes. I think anyone who wasn't worried about that flight was foolish. I think I get worried for every launch, we're worried about every launch. Over the elation after the launch, I'm nervous about launches. Every launch—COTS launch, CRS [Commercial Resupply Services] launch, Cassiopeia launch—any launch, I'm nervous. But you get over that. Dragon's in orbit, Dragon is doing what she's supposed to be doing.

I was at the Cape [Canaveral, Florida] for both the launches, so I was not here when Dragon reentered on the first [demo] flight in December of 2010. Unfortunately I wasn't here, but I was here for the flight [Falcon 9] in June [2010]. Elon and I switched. Elon was at the Cape for the first Falcon 9 flight in June, and he wanted to be here for the Dragon flight in December. I went to the Cape for the launch. I missed Dragon's reentry, but it all sounded great from there. The Cape team is much smaller, so it wasn't the mosh pit that we have here, but exciting nonetheless. Successful launches are amazing.

The berthing event—funny that it's the term "berth" with an e instead of an i, but it was a little bit like giving birth, because it lasted a long time. Longer than we had anticipated, this [demo mission] in May. We were struggling a little bit with, in simple terms, the focus on our proximity operation sensors, both the LIDARs and the thermal imagers that we had. There was a higher than anticipated glint off the JEM [Japanese Experiment] Module, which was throwing off our thermal imagers, and so our thermal imagers were not agreeing with our LIDARs.

You have to have two separate sources to independently tell you how far away you are. I wasn't actually sure we were going to make it. The two sources were not converging. One of the GNC engineers made a brilliant call. Instead of having the ISS telling you to get out, which would require a rendezvous, we had another command retreat. We were struggling with getting these sensors to agree, and luckily he called a retreat. Because otherwise I think they would have said, "abort," and then we would have had to spend 24 hours going around and coming back.

That was a brilliant maneuver. We retreated and we're thinking, "What are we going to do to fix this? We've got this glint on the JEMs, how are we going to get rid of that?" Ultimately they did it in software. Physically I don't know quite how that worked, but it worked. We uploaded the software and they started converging. Thank goodness.

It was amazing. Extraordinary. I was in the control center at the time, we started at four in the morning, and then people are just screaming out here. There's probably 1,500 people outside there, screaming and crying and hugging, and it was really hot and sweaty. Then I came out of the room, and we had this lineup of tables full of champagne and champagne glasses, so I started popping champagne. Pouring champagne at like four in the morning, and I hadn't showered.

WRIGHT: It was a good time.

SHOTWELL: It was a good day. It was kind of a memory of a lifetime. Yes, I'm good.

WRIGHT: The COTS program allowed you an opportunity as such a small and a young company, and these last five, six years have been so full. What kind of impact do you think that this opportunity has had on your company, to put you where you want to be for the future?

SHOTWELL: We would not be the company that we are today without the support of NASA. I think both technically as well as financially, and the kind of moral support. I don't know what the world would look like without that program for SpaceX. It would look very different. We wouldn't have this beautiful factory; we wouldn't have this lovely conference room with these incredibly comfortable chairs. Yes, this is as much NASA as it is SpaceX here. We'd probably be limping along, trying to change the world, but limping instead of running.

WRIGHT: Do you feel from what you've learned these last years that you are in a position now to possibly even change the market more?

SHOTWELL: Oh, there's no question. No question, we already have. As a matter of fact, last year any commercial mission that was competed in the Falcon 9 class we won. Here in the U.S. and overseas. So NASA helped develop a capability where the U.S. can finally regain dominance in launch. We owned it in the '80s and the early '90s, and we just let it go.

WRIGHT: Rebecca, do you have some questions?

HACKLER: One thing I wanted to ask—your role is officially the business manager, business developer. But you're also very technically competent; you have degrees in engineering. Did that impact the way that you interacted with NASA? I have to imagine it helped in the negotiations.

SHOTWELL: Having an engineering degree has helped enormously. When COTS was awarded I was the Vice President of Business Development, and then when we were awarded CRS Elon asked me to be President. Which I was thrilled about—leery about and thrilled about at the same instant, because I did want a little bit broader reach on the technical activity. Not just the legal, the [Capitol] Hill, the sales, and the finance. I really felt like we needed to kind of pull together in one piece.

Knowing your product—and I don't mean knowing like reading a brochure, but really knowing how things work, knowing your product technically, and then knowing your company operationally, from a management perspective, is enormously helpful in closing any deal. If you can answer a question right away, you eliminate any concern in your buyer's mind. If you have to wait three weeks while you go back and get the answer, and try to figure it out and hash through it, you've allowed that customer to have that concern. And that concern becomes more real because anything becomes more real with time. There's no question that having the engineering background was enormously helpful. Always has been.

I am a total nerd, I love engineering. I'm an analyst, by the way, not a designer. I am not a creative person. I have no creative bones in my body at all. I'm an analyst, but I love that.

The only analysis I get to do now is financial analysis, but still, for proposals, I go through the numbers, "I think that's too many hours," and you run through it and how it turns out. Yes, I'm a nerd. I'm very proud of being an engineer.

HACKLER: If you can spare just one more minute, what was the biggest challenge for you in working with putting this COTS demonstration ability together, and working with NASA?

SHOTWELL: It was really keeping the company going financially while we were struggling. That was my contribution primarily. I didn't get to do as much engineering as I would have liked to, but continually convincing customers to invest in SpaceX, and to take the risk associated with buying launches from us. I was focused on keeping the company alive, keeping people paid while we were struggling and getting through it. Because I knew we'd get through it. Technically, I knew we would get through it. It was a matter of could we get through it financially and stay stable.

HACKLER: Thank you very much.

SHOTWELL: Sure.

WRIGHT: Thank you, and good luck with it all.

[End of interview]