INTERVIEW WITH

Jill Prince

BY DON COHEN

Jill Prince has been an aerospace engineer at Langley Research Center since 1999. She was recently awarded a Women in Aerospace Achievement Award for her work on autonomous aerobraking. Don Cohen spoke to her at NASA Headquarters in Washington, D.C.

COHEN: Let's talk about your aerobraking work at Langley, maybe starting with a description of what it is.

PRINCE: Aerobraking is using atmospheric drag on a spacecraft to slowly reduce the apoapsis altitude of the spacecraft [the furthest distance from the planet] to something closer to what you want the final science orbit to be.

COHEN: What is the reason for using aerobraking?

PRINCE: There are two ways to get a spacecraft into a desired orbit. You can use a lot of fuel and immediately put it into a small orbit, or you can save much of that fuel by capturing into a large orbit and using aerobraking to reduce the orbit size. It may take extra time, though. Mars Odyssey spent seventy-seven days aerobraking. For Mars Reconnaissance Orbiter (MRO), it was 145 days. But it's worth the fuel, mass, and cost savings of launching a smaller mass to Mars.

COHEN: Are you making decisions and adjustments all during that time?

PRINCE: Yes. What's tricky about aerobraking at Mars is you have so much atmospheric uncertainty that you can't rely on past missions to understand your current one. The data helps in your atmosphere modeling, but you can't fully rely on it. You have to go into the atmosphere in real time and figure out what's going on, what perturbations you are seeing.

COHEN: The perturbations are winds …?

PRINCE: Winds, density variability, polar warming. There are a lot of atmospheric effects going on.

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COHEN: So how do you respond to those effects?

PRINCE: You can make a maneuver at apoapsis, the furthest distance from the planet, to affect your altitude at periapsis, the closest distance to the planet. You can therefore control your periapsis altitude but not much else. There are so many things to predict, model, and analyze: you don't know exactly how dense the atmosphere is going to be in the next orbit. You have uncertainties in aerodynamics. You have uncertainties in temperature modeling. Over the past few years, we've tried to develop the idea of autonomous aerobraking to put a lot of the work that has been performed on the ground onto the spacecraft itself.

COHEN: I've always been impressed by the amount of forethought that goes into planetary missions—having to imagine conditions that are going to arise millions of miles away and years later.

PRINCE: You have to preplan. I spent five years on Mars Phoenix entry, descent, and landing. That was a seven-minute descent. Five years for seven minutes. It's a long time planning to make sure that you know what's going to happen, within certain bounds. We don't just show up when the spacecraft gets there and say, "OK, where are we going to go next?"

COHEN: What has it been like working with project managers and engineers, contributing your knowledge to their plans and designs?

PRINCE: It's always been a good experience. The missions I've worked on have been at different centers across the country and in different industries. For the three missions that I was a part of mission operations, we were at Langley working with project managers at JPL [Jet Propulsion Laboratory]. We work very well across the country. On Mars Odyssey, we had a three-hour time difference. It was perfect. We'd get data in the morning and have a three-hour jump to get the rest of the team the data we all needed to make a decision early in the morning [in California].

COHEN: So there are sometimes advantages to working at a distance. Did you also spend time out there?

PRINCE: For Mars Odyssey and MRO, the Langley team all went for meetings every once in a while, but we did all of the Langley aerobraking work at Langley. We stayed in our separate locations. For Phoenix, I spent a month at JPL before the landing, trying to optimize the trajectory to target the planet exactly where we needed to go. For the two orbiters, aerobraking meant very long operations. Entry, descent, and landing was a one-shot deal. You don't get a couple of orbits to toe-dip in the atmosphere to see if it's to your liking. You have one shot and that's it. It was 145 days of excitement contained into one.

COHEN: Did you find—when you worked mainly from Langley—that you had to get to know the people you were going to work with at a distance?

PRINCE: Yes, you can't glean personality from a phone call or an e-mail. You have to talk with them one on one and spend time with them to know how they work and how they best receive data.

COHEN: How did you make that happen?

PRINCE: There were usually face-to-face meetings for years beforehand. The Langley engineers I work with and I are usually in the same building, and that is always a very easy working experience.

COHEN: Were you involved in projects from the beginning?

PRINCE: I joined the Odyssey team maybe a year prior to launch, if that, and I think Langley got involved at a relatively late date. For MRO, we started a lot earlier and were more involved in the aerobraking mission design.

COHEN: Did that earlier start mean differences in how the work went?

PRINCE: It did. There are fewer problems down the road when you can design the mission based on its atmospheric flight. If you don't take that into account until later in the mission life cycle, there can be some problems along the way that you might have to find a less-than-optimal solution for. In entry, descent, and landing, that's particularly important. You should really design the mission with entry, descent, and landing in mind, not design a mission and figure out that last seven minutes later.

COHEN: Can you give me a specific example of how the atmospheric flight analysis has influenced mission design?

PRINCE: On Mars Phoenix we discovered a year or so before launch that there was an issue with the reaction control system. There was the potential that the interaction with the atmosphere at upper altitudes would interfere adversely with the thrusters being fired so that when you thought you were firing thrusters to control the spacecraft in one direction it might have produced the opposite effect. You think you're going one way and the atmosphere is going to force you to go the other way. Because of that analysis, the team decided not to fire the thrusters at all. Instead of a controlled flight hypersonically, we left it uncontrolled. If we had tried to control that spacecraft in the upper atmosphere it really could have been problematic.

COHEN: How did you discover that problem?

PRINCE: There was a joint effort going on with Mars Science Laboratory, which will launch this year. Some of the analysis the aerothermodynamicists were doing at Langley discovered the potential. They ran some wind-tunnel tests, did computer modeling, and found this problem. We ran the aerodynamic uncertainties in a trajectory simulation and confirmed that it could be an issue. It was then shared with the Phoenix team so we could quickly mitigate this risk.

COHEN: I know landing a large spacecraft on Mars is a major challenge.

PRINCE: If we try to land anything of higher mass than Mars Science Lab (about 1 metric ton), we will have issues. We're working with Viking technology that's fifty years old. We need new technology to be able to land anything bigger than 1 metric ton on the surface on Mars. Otherwise we can't do it without a boatload of fuel.

COHEN: What direction might those new technologies take?

PRINCE: There are several studies looking at several different options: inflatable atmospheric decelerators, both hypersonic and supersonic; supersonic retro-propulsion. An entry, descent, and landing analysis wrapping up now has been investigating architectures to get a large mass to the surface of Mars.

COHEN: **How did you get into aerobraking in the first place?**

PRINCE: I jumped right into it. I went to George Washington University for my master's degree in engineering. Their program was physically located at Langley. I archived some Mars Global Surveyor data—the first Mars aerobraking mission. My thesis was on autonomous aerobraking. I've had the same phone number and I've been working with the same group of people ever since. It's been fabulous.

COHEN: **How much of what you know came from school, how much from being on the job?**

PRINCE: I would say 90 percent from job experience. You have to have the background to understand the physics behind the orbit, but you learn the operations from experience.

COHEN: **How important was mentoring in the early part of your career?**

PRINCE: I would say mentoring not only had an extremely positive effect on the early part of my career, but I still have mentors and often look to them for guidance. I don't think there is a point in any person's career where she or he should think they don't need somebody else's input.

COHEN: **What kinds of things do people who have been around a long time know that newcomers don't?**

PRINCE: People who have been around a while know more about how to handle situations, how to deal with other people. But they also give technical advice and have experience to back it up. For example, I wouldn't have known in my first aerobraking mission why certain atmospheric data didn't line up with what I would have expected. "Why is the density acting so strangely here and not over here?" Sometimes you have to ask somebody who has been there before. Maybe I would have figured it out for myself in ten years, but having someone with decades of experience is helpful.

COHEN: **Now that you've been with NASA over ten years, what kind of advice would you give a new employee?**

PRINCE: I'd throw them in the deep end. I'd tell them to dive right in and see where you can go. If you're given an opportunity, make the best of it. You can't let an opportunity go by.

COHEN: **Which is what you did.**

PRINCE: My advisor at George Washington helped to throw me in that deep end. He said, "I have a couple of students that I'd like to have help out Mars Odyssey." The engineers at Langley didn't know who I was, but they said OK. There was a lot of trust. When you're given the responsibility of working on a flight project you have to live up to that.

COHEN: **Were you terrified? Excited?**

PRINCE: I was too naïve to be terrified.

COHEN: **I've heard similar stories from other people at NASA—that they were given responsibility for important work from the beginning.**

PRINCE: If I hadn't been put on a project I had so much fun doing, I don't think I would have stayed. I was fortunate to really like what I got into, and in the past ten years I've been fortunate enough to work three different flight projects. I haven't left Langley other than for my current six-month detail at Headquarters.

COHEN: **You're working with Bobby Braun on new technology?**

PRINCE: Yes, I'm working in the Strategic Integration Office in the Office of the Chief Technologist with Bobby Braun and James Reuther. Along with others, I work on activities including the technology road mapping that NASA is doing to define the pathway of our technological future for the next twenty years or so. I'm here as part of a mid-level leader program that is in its pilot year.

COHEN: **It's a leadership development program?**

PRINCE: Yes. Part of that program is a three- to six-month detail.

COHEN: **What is the biggest challenge of the assignment?**

PRINCE: Understanding a much broader scope of technology development is a challenge. I have been focused on entry, descent, and landing for a while. It is exciting, yet still a challenge to open that

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lens a bit and learn about technologies in other areas.

COHEN: So do you see yourself as a technician or a manager?

PRINCE: I've been an assistant branch head at Langley since 2007. Recently at Langley I've been doing a little more managing than technical work. I think I'm OK with that. Having an assistant branch head job is great because I have a supervisory role but I can keep playing with the technical toys.

COHEN: How has the work at Headquarters been going?

PRINCE: We're forging on, trying to push technology as far as we can with what we have available. We're wrapping up the technology road-map efforts right now in hopes of getting several road maps to the National Research Council that they can improve upon and help out with our technology pathways in the future. They are amazing products. It's inspiring to read what people have come up with and think about where NASA is going to be a couple of decades from now.

COHEN: Bobby Braun has talked about the importance of failure to innovation.

PRINCE: Sometimes experiencing failure is the best way to improve the current technology. When people talk about NASA, "failure is not an option" is one of the first catchphrases you hear. When you're dealing with technology (not human spaceflight, of course) that's not necessarily the attitude you want. In building successful technology programs, you push the boundaries and strive for innovation. Sometimes you run into the proverbial unknown unknowns. We want to learn and understand all we can in our technology efforts but we have to be willing to take risks and understand that failure is sometimes an outcome. But it's hard to change a culture mind-set. And several high-profile NASA failures remain fresh on many people's minds; in my area of work, those include the two failed Mars missions in 1999.

COHEN: Would you say those two Mars failures were total losses or were they learning opportunities?

PRINCE: We learned a lot, especially from Polar Lander. We learned many potential causes of failure and that contributed to the success of Phoenix, which was a sister spacecraft. Even though I didn't work on Polar Lander, I learned a lot from it.

COHEN: You recently got a Women in Aerospace Achievement Award.

PRINCE: I did. I was extremely honored by this award—what an amazing organization. It was specifically for my work in the development of autonomous aerobraking.

COHEN: Has being a woman engineer ever been a problem for you?

PRINCE: If anything, I think it has given me more opportunity. Because they are a minority in engineering, you typically remember the women you see in engineering. Sometimes that's positive.

COHEN: As a student, did you run into teachers who said, "You're a woman; you can't do math or science?"

PRINCE: Absolutely not. I get a lot of speaking requests to try to get young girls interested in math and science. I've probably talked to twenty different schools. I talk to Girl Scouts. I've talked to astronomy clubs. I recently gave a talk to a group of female physicians and attorneys in Syracuse, New York. Groups of women like to see another woman talking to them. I get a lot of students ask their teachers, "She's not an engineer, is

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she?" I think I'm asked to speak because I'm a woman, but I don't mind that anymore. I used to.

COHEN: Used to mind it because you thought of yourself as an engineer, not a female engineer?

PRINCE: There was a little of that. I think I've gotten over it. I realize that speaking to students is a great opportunity to motivate other young women into technical fields, and if I can do that, what better way is there to increase the diversity in those fields?

COHEN: How has the response to those talks been?

PRINCE: I keep doing it because of the great response I get. I don't just do it for kids; I do it for myself, too. It's very gratifying. It makes me remember what a wonderful job I have. It's amazing how smart kids are. They pick up stuff very quickly. They ask some really good questions. It's impressive and inspiring.

COHEN: What are your goals for the future at NASA?

PRINCE: NASA is an amazing agency. We do things here that no other organization can. We pursue seemingly impossible challenges and improve our way of life along the way. I'm having so much fun right now, it's hard to think much about the future. When I stop having fun, I'll think about what's next. ●