INTERVIEW WITH

Robert Braun

BY DON COHEN

Robert Braun was named NASA Chief Technologist in February 2010. His NASA career began at Langley Research Center in 1987. From 2003 until his return to NASA, he led a research and education program at Georgia Tech focused on designing flight systems and technologies for planetary exploration. Don Cohen and Academy for Program/Project and Engineering Leadership Director Ed Hoffman talked with him at NASA Headquarters in Washington, D.C.

COHEN: How do you see your role as chief technologist at NASA?

BRAUN: I am the administrator's primary advocate and advisor for technology matters across the agency. The president's FY11 budget request—yet to be approved by Congress—is what I would call a technology-enabled approach to exploration. That plan includes a wide variety of technology programs within the mission directorates and a new technology program outside the directorates. I directly manage the technology that's outside the mission directorates and work with the mission directorates' associate administrators on their technology portfolios. As a technology-oriented agency, it's very important that NASA communicate a single message about what we're doing in technology. One of my roles is to develop a coordinated policy to communicate the benefits of our technology programs, both to the space program and to life here on Earth.

COHEN: I know your job is new, but can you give an example of the kinds of things you've been involved in so far?

BRAUN: Coming into NASA from my university job, I thought I was going to be solely focused on developing plans for NASA's new technology programs. I have been doing that, but also much more. I go to the major policy meetings to

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speak up from a technology perspective. I've testified in the Senate Commerce Committee in a technology-oriented hearing along with the president's science advisor, Dr. John Holdren. I've spoken about the importance of technology at many of the NASA centers, at universities, and to industry groups. And I'm working closely with the mission directorates' associate administrators, helping to plan their technology programs.

COHEN: So the job is a lot more public than you expected.

BRAUN: It's a lot *more* than I expected. And more public.

HOFFMAN: Are there organizations out there that you'd like us to be more like or get closer to?

BRAUN: Yes. I've been meeting with my counterparts at other government agencies. I have a great relationship with Dave Neyland, the director of the TTO [Tactical Technical Office] at DARPA [Defense Advanced Research Projects Agency]. I've also spoken with leaders at AFOSR [Air Force Office of Scientific Research]. I'm meeting today with the director of ARPA-E, the new advanced research project within the Department of Energy.

For NASA to be successful in technology, we need to learn lessons from across the government. And we need a model that spans our many different kinds of technology programs. There is no one-size-fits-all technology program. We need programs that are wide open and searching for the best ideas across the globe—involving the NASA centers, our university partners, folks in industry, and our international partners. We also need the capability to fund high-value technology in strategic areas. And we need to have the flexibility to allow failure. If we take large risks, some of our technology programs will fail. In my view, that's a hard sell at NASA. The most frequent motto you hear at NASA is "failure is not an option." In our human spaceflight program, that is the correct mantra. But as we go from human spaceflight to large, flagship robotic missions, to small robotic missions, all the way down to technology demonstrations, we need to be able to dial up the risk we're willing to take. If we're afraid to fail down at the technology level, we won't make the major advances that are critical to our future and that our nation has come to expect of NASA.

HOFFMAN: If you tell project managers that you expect high performance within cost and schedule, the first thing they try to do is limit risk by limiting new technologies.

BRAUN: That's absolutely right.

COHEN: Can you create room in projects for three or four approaches to the same technology issue?

BRAUN: What we're going to do is identify the capabilities that we need. For instance, we need to be able to land the equivalent of a two-story house on the surface of Mars. There are several technological approaches to doing that—all in their infancy. You can imagine teams of folks from around the country or perhaps around the world responding with multiple technological solutions. What we would like to do is fund several of these to the point at which they're mature enough for us to make an intelligent decision about which solution is likely to pan out. Then we would put additional funds toward that particular solution and take it to a flight-test program. Only then, when it's been flight proven, would we bank on that technology.

COHEN: Is a willingness to fail one of the lessons learned from DARPA?

BRAUN: Absolutely. DARPA's philosophy is that about 10 percent of the missions they invest in will actually make it through to some future capability for the war fighter. That's their goal. They fund parallel teams taking parallel approaches, and they're willing to terminate these activities when they need to. They do that all the time. At NASA, we haven't had the fortitude to do that. We start technology programs and don't turn them off. We need to pursue advances which will not all succeed and use strong program management skills to terminate activities that are not bearing fruit.

COHEN: If people believe failure is not an option, that's hard to do.

BRAUN: I agree. Just last week two interesting news stories about failures came out a day apart from each other. The air force and DARPA together flew a hypersonic vehicle at Mach 20. Then they lost control of the vehicle, and it was terminated. The newspaper headline was, "DARPA breaks world speed record." Further down, the article talked about how the mission was a failure. Around that same time, NASA had a balloon crash in Australia. That was a headline story on CNN. Admittedly, there was a fairly dramatic video of the balloon crash—that's part of the reason it got hyped in the media. We are just now beginning to investigate the specifics of that particular failure. Was it a failure because we were attempting to take too large a step or because we made a mistake? In my view, if it was a failure because we were taking a large step, that should be acceptable.

COHEN: Jim March at Stanford has talked about the fact that the failure rate for innovative work is very high.

BRAUN: In its early days, NASA was good at taking risks and accepting the fact that not everything was going to succeed. Over time, we've gotten more and more risk averse. That's one of the things I'm trying to help change.

COHEN: In addition to trying to make failure more acceptable and funding potentially innovative work, are there things that can be done to foster innovation?

BRAUN: I think the amount of innovation in an organization is largely a function of how that organization values innovation. If you incentivize smart, creative people to be innovative, they will. If, instead, you incentivize them to work rigorously on one program for their entire career, they will do that. One of the things I think we need is more small projects. We need a greater diversity of projects and informed risk-taking so that we can stimulate innovation, particularly in the

NASA field centers. The centers are full of creative, bright, and talented people. We need to unleash their potential.

COHEN: So you see the issue as innovators ready to be unleashed, rather than having to train people to think innovatively?

BRAUN: Yes. Innovators are going to come out of the woodwork when they're incentivized to do so. Previously, there was no place in NASA for their ideas to go. There was no chance for those ideas to mature even a little bit, and they stayed in concept-land forever. In many cases, there wasn't even enough funding to write a paper, let alone take an idea from a paper study to a laboratory test or a flight test to prove that the relevant physics made sense. Over the last few years, funding to mature new ideas at NASA has become very tight. As part of the president's FY11 budget request, we are creating a new program called the Center Innovation Fund that the center directors will control and manage. They'll be getting some guidance from Headquarters on the kinds of activities the fund can be used for, but basically they'll be able to make quick decisions at the field centers about new ideas. Think of it as seed money to get new ideas moving so they can get to the point where we can see if they have any merit and, if so, how to transition them into a larger technology program or a flight program. Of course, I would also like to hire more people, and young people in particular. I'd like to hire one hundred young fresh-outs a year to each center. That would be another way of pushing innovation. You see this at Google, for instance. They are constantly bringing in new people and looking at new ideas. Not everything Google tries works. They accept failure and that helps their culture of innovation.

COHEN: In your earlier work with NASA or elsewhere, have you been part of innovative programs?

BRAUN: The first flight program I worked on as a young engineer at NASA was Mars Pathfinder. Pathfinder was our first attempt to go back to Mars after the 1992 failure of the Mars Observer, a billion-dollar orbiter that reached Mars, pressurized its fuel tanks, and then was never heard from again. Following that failure, the associate administrator for the Science Mission Directorate and a project manager at the Jet Propulsion Laboratory [JPL] put their careers on the line and created Mars Pathfinder. Pathfinder was designed to land on the Mars surface—something much harder than going into orbit around Mars—and that hadn't been done since Viking. And they were going to do it for $250 million, a quarter of the Observer budget. The best-known Mars Pathfinder innovation was the airbag system that allowed the lander to bounce and roll to a stop. The Sojourner rover was another—the first rover on another planet. Mars Pathfinder accomplished its science objectives and its technology objectives, but that's not the whole story.

Prior to Pathfinder, there was no Mars program in NASA and no Mars community of scientists and engineers. The public was not really engaged in the idea of sending spacecraft and eventually humans to Mars. You may remember that Pathfinder set a record for the number of Web hits after its landing on July 4, 1997. Public interest went through the roof. Shortly after that, the Mars program was established; it's been a funded line in the NASA budget ever since. The Mars Exploration Program Analysis Group, a collection of hundreds of scientists and engineers from around the world, was formed. That group provides scientific advice to the program on how it should proceed in the future. It has been so successful that there's now a VEXAG for Venus and an OPAG for the outer planets. My colleagues who cut their teeth on Mars Pathfinder went on to work on later Mars missions. Some worked on the Mars Exploration Rovers and on various Discovery and New Frontiers missions; some are now working on the Mars Science Laboratory. So when I think back on Pathfinder, I don't just think about its science and technology success. I think about the fact that for $250 million—a relatively small amount of money then and today—Mars Pathfinder was a game changer for the way we do planetary science. Innovative technologies can lead to entirely new ways for us to go about our business of aeronautics and space exploration.

COHEN: Among other things, they can create new communities.

BRAUN: Yes. New communities, new innovators, new businesses. They can affect the U.S. economy through technological stimulus.

HOFFMAN: People at NASA sometimes make fun of the term "game changing" because it's become so ubiquitous.

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Maybe you can talk about what game-changing technology means.

BRAUN: I think we'd all agree that the Internet was a game changer. That the cell phone was as well. These technologies changed the way we do business. Those are everyday examples. NASA can change the way we go about future missions. What we're doing in NASA's technology programs is investing in a broad portfolio of technologies so that the success of some of them will enable future NASA missions that we cannot even imagine today and will allow us to go about our currently planned future missions in entirely new ways that significantly reduce the cost or the travel time. What about enabling not only planetary exploration but interstellar exploration? We can't do that with today's technology because of the time scales involved. We're talking about investments that could allow entirely new ways of doing these missions. That's my definition of game changing.

COHEN: So you see the new technology initiatives directly supporting NASA's flight missions?

BRAUN: Yes. It's not that we need to do research and technology development instead of flight systems or operations. We need all three. But without research and technology development, we'd just be doing incremental missions. Science missions based on existing technologies would make scientific advances, but the pace at which those advances will be achieved would be slow. We certainly wouldn't be doing the kinds of human exploration missions that the president is talking about. We can't do human deep-space exploration without an investment in technology. What I believe is required, and the president's budget request highlights, is balancing these three long-standing core competencies at NASA: research and technology development, flight systems development, and mission operations. All three are required for NASA to be the cutting-edge agency that the nation expects it to be.

HOFFMAN: Seventy percent of our scientific missions are international partnerships. Universities drive a lot of the science. Anything that comes out of here will permeate these other places.

BRAUN: Reaching out broadly and partnering is a big part of the job. For an idea to succeed and be picked up by somebody else, a few things have to happen. First, you have to have the ideas, and I believe that NASA has

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them. Second, you have to have a place to incubate and mature those ideas. That hasn’t existed previously, but it will if the president’s budget request is approved by Congress. Third, you have to make those ideas public, partnering with academia, with industry, with our international partners. If, for whatever reason, NASA can’t capitalize on a particular good idea today, perhaps the commercial world will pick it up. Perhaps another government agency will pick it up. But they have to know about it first.

COHEN: Can you give another example of a mission you were involved in that generated valuable new technology?

BRAUN: Right after Pathfinder I worked on something called the Mars Microprobe mission, a New Millennium project. The New Millennium program within the Science Mission Directorate was the last significant program that enabled people to take technologies into a flight-relevant environment and prove them. Unfortunately, it’s been in decline from a funding perspective over the last few years. In this particular New Millennium project, a handful of us developed a basketball-sized aeroshell called a single-stage entry system because it didn’t have deployables: it didn’t have a parachute, it didn’t have airbags. This system was designed to fly all the way through the Mars atmosphere, impact the ground, and push a penetrator into the subsurface. We tested the system and it looked pretty good. We did a lot of analysis. We flew it. Two of the systems flew all the way to Mars along with the Mars Polar Lander in 1999. The whole New Millennium activity cost $25 million. They were lost with the lander. Some people would say that was a failure.

The next mission I went to work on was the Mars sample return Earth-entry vehicle. This is a highly valued component of a highly valued mission, something the Mars community is very interested in doing one day. The Earth-entry vehicle is the piece that would bring the samples back from Mars safely through the earth’s atmosphere for recovery. My team was selected competitively to develop that system. We proposed a single-stage entry system based largely on what we had learned from the Mars Microprobe project. Mars Microprobe was a failure in the mission sense; I’m not trying to gloss that over. But the lessons learned, the experience gained by the people who brought us Mars Microprobe, was directly utilized in the development of a concept that is now the baseline for a very important future space-science mission. Single-stage entry systems have since been proposed by a number of organizations to return samples from comets and the moon. Another way you can tell whether you have a good idea is by the number of people who adopt it.

COHEN: You got $25 million worth of learning.

BRAUN: I learned just as much from the $25-million, rapid-development Mars Microprobe as I did working on the

$250-million Mars Pathfinder. One was a failure, one a success. Working on that "failure," I improved my skills as an engineer, I improved my systems knowledge, and I learned valuable lessons that I could apply to future systems.

HOFFMAN: A project is a project.

BRAUN: As long as you get to hardware and some sort of demonstration. It can be a ground-based demonstration; it doesn't have to be a flight. Too often we never get out of the paper phase. There are technologies for scientific exploration, human exploration, and aeronautics that have been documented in report after report for decades. A healthy technology program should allow people to take those technologies from the concept world, where they've been stuck for decades, and into the flight world (where "flight" can mean ground-based testing, atmospheric testing, low-Earth-orbit testing—whatever is needed to prove the core technology). That's what's been missing in NASA over the last decade.

COHEN: Are there ways, other than assertion, to create a culture where valuable failure is OK?

BRAUN: It's a long-term process. There are several approaches I'm working on. One is communicating. We need to assure the NASA workforce, industry, and academia that informed risk-taking is acceptable. The current system forces them to act as if failure is not an option even for a $25-million ground-based test. The second step is to design for failure through our acquisition strategy—to actually plan on having a certain percentage of failures. The third piece is to set up the technology development program with defined gates where one plans to terminate activities, and everyone knows that it doesn't mean the end of the world. If we're going to have five parallel efforts for a given capability, at some point we're going to terminate four of them.

HOFFMAN: Today you get communities locked in to self-preservation, as opposed to going on to the next cool thing.

COHEN: When people hear stories of someone promoted because of an interesting failure, they'll be convinced.

BRAUN: I intend to celebrate failure. Not because we made a metric-to-English conversion error. Failure because we went after a large goal, made progress, and did all the right things, but didn't quite make it to that goal. I'm sure they're celebrating in DARPA today because they flew a Mach-20 vehicle. Did they succeed in their objectives? Absolutely not.

HOFFMAN: Before we finish, tell us about what prepared you for where you are today.

BRAUN: A breadth and diversity of educational and professional experiences prepared me for this assignment. I grew up with a father who pointed me in this direction at an early age. He was an electrical engineer at the Johns Hopkins Applied Physics Laboratory. I had excellent educational opportunities at Penn State, George Washington University, and Stanford. I've also worked for extended periods of time at three different NASA centers. I was always a Langley employee, but I was often on a development assignment: at Ames Research Center for a couple of years, at JPL for Mars missions. When I started at Langley, having more senior people I could go to at any time with any question and who never told me that my ideas were stupid was a tremendous asset and learning experience. Langley sponsored both my master's degree and my PhD through various Office of Education programs. Also very important was leaving the agency in 2003 and going to a major research university like Georgia Tech, where I could view the agency from the outside and see the immensely strong capabilities of the outside world. Previously, inside NASA, I hadn't looked outside as much as I should have. Coming back from the outside, I see the value in these partnerships much more clearly. ●