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BIG THINKER: Bobby Braun's job is to take NASA farther—past moon shots and space shuttles, to Mars and beyond.

DEPARTMENTS

NASA/CARLA CIOFFI

ON THE COVER: In a shot reminiscent of his iconic "Afghan Girl," Steve McCurry '74 A&A captured this image of a Rabari Indian girl, a highlight of the world's last roll of Kodachrome film. See p. 32.

TO BOLDLY GO

NASA was once the symbol of America's technological prowess, but for 30 years our astronauts have been stuck in low-Earth orbit. Can Bobby Braun help NASA get its mojo back and blast humankind to Mars and beyond?

By Jason Fagone '01 Com/A&A
Photo by Douglas Sonders

IT USED TO BE THAT WHEN IMAGES CAME BACK FROM THE SHIPS we blasted into space, the pictures painted themselves on Earth's viewscreens with painstaking slowness, line by line. Such was the case on the afternoon in July 1976 when a 11-year-old boy was led into an auditorium at NASA's Goddard Space Flight Center in Maryland.

A neighbor who worked at NASA had brought the boy, Bobby Braun, to Goddard to let him witness a scientific milestone: the first touchdown of an American spaceship on another planet. **Braun '87 Eng** remembers the feeling of anticipation at Goddard as the first image from the landing craft called Viking 1 began to flicker across the auditorium's screen. Was Viking damaged? Had its communications equipment or camera lens been mangled? With each new line of the image, it became increasingly clear that the answers were no. When the NASA employees in the room were certain >>>

that Viking had landed intact, they exploded in glad cries, jumping up and down and awkwardly splaying their limbs "as only engineers can do," Braun says, laughing. "And I was kinda hooked."

In 1976, Braun could never have imagined that it would take America another 20 years to return to the Mars surface. But the long wait allowed Braun to achieve a remarkable feat of symmetry. After graduating from Penn State, he got a job at NASA's Langley Research Center in Virginia, specializing in "orbital mechanics," the physics of how ships and satellites move through space and through atmospheres. Within a few years, Braun found himself assigned to a high-stakes, high-risk mission called Mars Pathfinder—the first attempt since Viking to put a lander on Mars. On the day of Pathfinder's touchdown in 1997, Braun was present at a NASA center once again, just like with Viking. But this time he was no spectator. He was a 31-year-old engineer helping to control a hunk of metal screaming toward the Martian surface at 16,600 miles per hour.

Pathfinder was such an innovative project that any description of its design sounded almost crazy. The Pathfinder engineers—scattered at various NASA centers across the country—planned to sling the landing craft through the harsh, thin Martian atmosphere, then use a parachute to slow it down. At the last minute, the engineers would deploy four large airbags to cushion the landing. The craft would bounce like a beach ball across the Martian surface. Once at rest, the airbags would deflate and the lander would open up like a flower, revealing a "rover," a tiny solar-powered car packed with cameras and probes. The rover, dubbed Sojourner, would then roll down one of the lander's three petals and start tooling around the landing site, a rocky plain created by ancient Martian floods.

BRAUN FOUND HIMSELF ASSIGNED TO A HIGH-STAKES, HIGH-RISK MISSION CALLED MARS PATHFINDER—THE FIRST ATTEMPT SINCE VIKING TO PUT A LANDER ON MARS.

Braun's job was to help land Pathfinder safely, choreographing the complex ballet of gravity and machinery performed in the final moments of truth. "When we started, we didn't know how hard it was going to be," he says. Key elements of Pathfinder's landing strategy had never been tried before—not the airbag concept, not the petals. And certainly nothing this ambitious had been attempted on a budget this meager. The total mission cost was $270 million—chump change in NASA terms, about one-fourth the cost of the previous Mars mission, in 1993, which had failed spectacularly. That year, the $1 billion Mars Observer approached the orbit of Mars and was never heard from again. Public frustration over the apparent waste of taxpayer money was so widespread that even Jimmy Buffett took a shot at NASA in his song "Fruitcakes": *We spent 90 jillion dollars trying to get a look at Mars / I hear universal laughter ringing out among the stars.* Braun believed that there was an 85 percent chance that Pathfinder would work and a 15 percent chance it would provide more lyrical fodder for Jimmy Buffett.

On July 4, 1997, Pathfinder touched down on Mars. It bounced as high as 50 feet in the air and landed intact, right-side up. Then it beamed a series of images back that popped up on the screen all in one chunk, not line by line like the old days. The images showed a lovely rocky plain stretching to an umber horizon in all directions, and their resolution was so high that Braun and his NASA buddies, whooping and high-fiving in their control

centers, could discern the shape of the smallest pebble. But Braun didn't need multiple images. He only needed that first one, the one that showed the lander safely at rest on Mars, cradled by the deflated airbags that had done their job: "I worked five years for that one picture." The puppy-like Sojourner rover soon began to amble across the Martian surface at 1 mph, licking ancient rocks to determine their chemical composition. Over the next two years, Sojourner gathered more than 2 billion bits of scientific data, laying the foundation for a human mission to Mars.

"I thought, 'Wow, this is great, I can't wait for the next mission,'" recalls Braun, who in February 2010 was named NASA's chief technologist, the top technology guru at the agency and the first person to hold that position in almost 10 years. "I thought they were all going to be this good."

WHAT HAPPENED?

FOURTEEN YEARS AFTER Pathfinder—the ultimate can-do aerospace mission of the past two or three decades—we're still at least two decades away from sending a human to Mars. Humans haven't braved the 240,000 miles to the moon since 1972. We haven't sent humans up to explore an asteroid up close or probe a rock on the surface of Europa or Titan, the tantalizingly weird and possibly life-supporting moons of Jupiter and Saturn. The basic technology behind chemical rockets hasn't really changed in 40 years. The space shuttle regularly tops out at a decidedly modest height of 250 miles, a little more than the distance from State College to Philadelphia.

To a guy like Braun—or to anyone who was inspired by the buzz-cut heroes of the Apollo era and assumed we'd follow their example, pressing farther and faster into space—this can be a frustrating state of affairs (although Braun praises the work of the shuttle engineers as "amazing"). Somewhere along the line, NASA seems

Braun was an engineer on the team that landed the spacecraft Pathfinder safely on Mars in 1997; he helped design the airbags (top photo, being tested in 1995) that cushioned the landing. Two decades earlier, as an 11-year-old, he had watched from an auditorium at Goddard Space Flight Center as Pathfinder's predecessor, Viking 1, touched down on the red planet (bottom photo).

NASA (2)

TEN THINGS ABOUT NASA'S CHIEF TECHNOLOGIST

1 Grew up in Rockville, Md. Father was an electrical engineer at the Johns Hopkins University Applied Physics Lab; mother was a hospital administrator.

2 As a high school senior, toured Happy Valley on a football weekend. Wound up studying aerospace engineering at Penn State.

3 Wrote his master's thesis at George Washington University on The Effect of Interplanetary Trajectory Options on a Manned Mars Aerobrake Configuration; later earned a Ph.D. from Stanford.

4 Lives on a small farm about 30 miles southwest of Atlanta with his wife, Karen, who has worked as a nurse and as a graphic artist, and three kids, Zack (16), Allie Grace (14), and Jessica (12). The kids recently got to meet astronauts Charlie Bolden (their dad's boss) and Buzz Aldrin in person.

5 Keeps globes of Mars, Earth, and the moon on his desk at Georgia Tech, for use in orbital mechanics lectures.

6 Is a fan of "Robonaut," NASA's robot astronaut destined for the International Space Station. Robonaut has a Twitter account: "Coolest thing about me is my hands! They make me one of the most dexterous robots on Earth, and soon the most dexterous in space!"

7 At a recent speech in California, was introduced by Pete Worden, director of NASA's Ames Research Center, as "the guy who's going to help us build starships and settle other solar systems, in between doing other cool things on Earth."

8 Told Engadget.com that he would love to go to Mars himself. "Absolutely. Well, my wife wouldn't let me."

9 Has spent years studying a "sample return" mission to Mars, which would involve landing a little rocket on Mars, retrieving a sample of Martian rocks and soil, and sending them back to Earth.

10 Believes that we are not "alone in the universe." —*JF*

to have lost its way. There are those who believe that the reason has nothing at all to do with technology. "NASA does not have a *how* problem," says John Pike, a space policy analyst at GlobalSecurity.org and the former head of space policy for the American Federation of Scientists. "NASA has a *why* problem. Why do we have NASA? What national purpose does it serve?"

This question was easy enough to answer in the 1960s. NASA existed to crush the Soviet Union. With the end of the Cold War, NASA morphed into a tool of diplomacy and detente; via the International Space Station, we showed that we could cooperate with our former enemies for the good of the world. Today, though, our enemies are stateless terrorists, not military powers, and NASA no longer has any obvious military rationale. In addition, private companies are increasingly vying to launch humans into space on their own ships. All of which raises the question: Couldn't we redirect NASA's $19 billion yearly budget to people trying to improve life here on Earth? To biologists looking for cancer cures, say? In an era of rising budget deficits, can we afford a space agency?

It's part of Braun's role as chief technologist to answer this question, and he does it on a couple of levels. First, he reels off the list of practical technologies that have emerged from space research in the past—not just Tang, but weather satellites, GPS navigation, the materials used in artificial hearts, new types of computer chips, tools for measuring Earth's climate, techniques for spotting cancer in MRI images, and on and on. President Obama has directed Braun and the rest of NASA to focus some of their intellectual capital on our country's technological challenges, as part of his government-wide "innovation agenda." The hope is that NASA advances in physics, and in the earth and materials sciences, will filter down to the

rest of us in the form of cleaner energy and, according to Braun, perhaps even "the ability to forecast major storms or natural disasters with sufficient time to warn people."

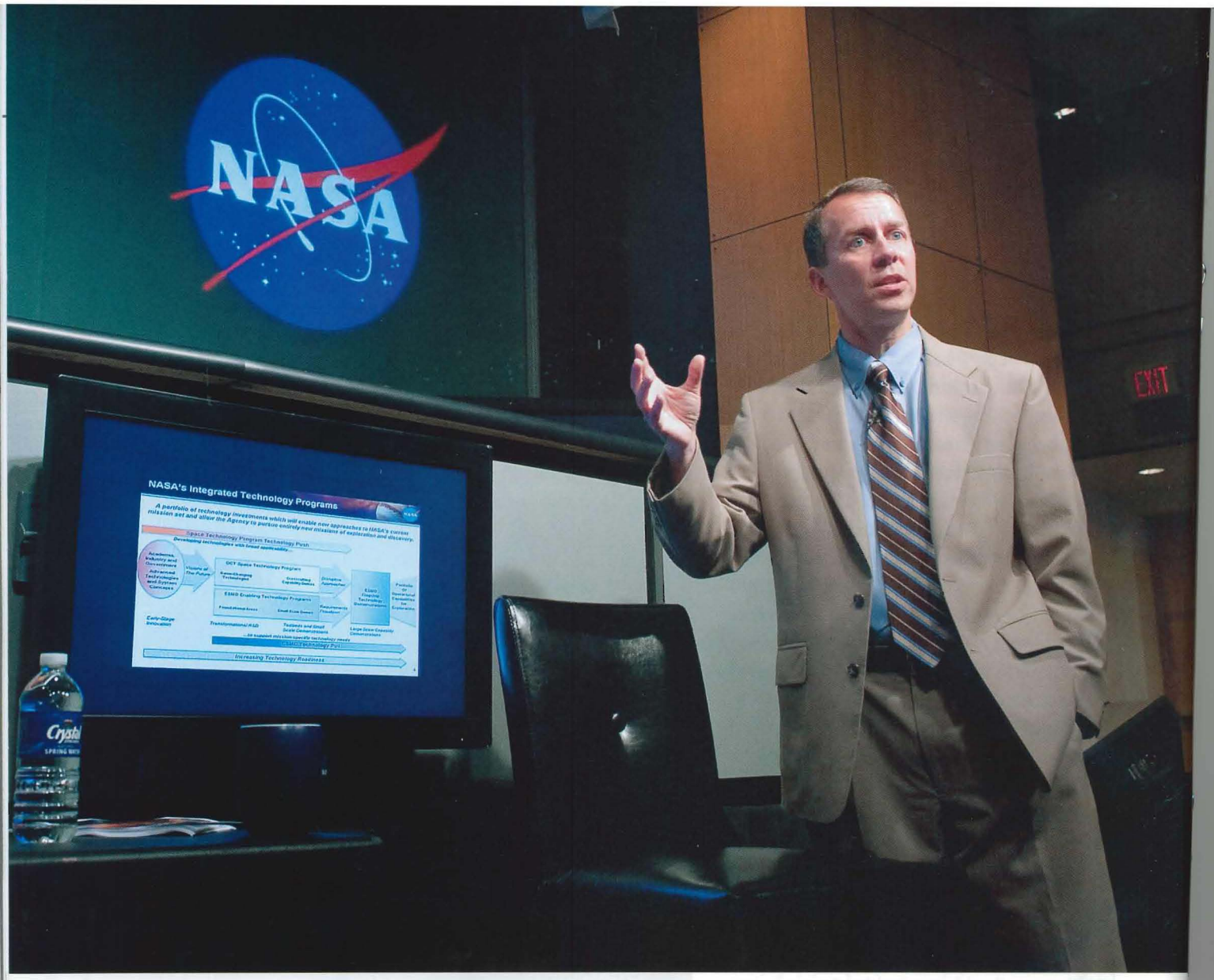
There are also the intangibles. NASA has always been a beacon to America's sharpest young minds in math and science—something Braun knows a lot about, because he came to his new job, which is headquartered in Washington, D.C., from a professorship at Georgia Tech, where his students worked on developing creative approaches to future space missions. (Braun still spends many Fridays at Georgia Tech, working with his grad students.) Since last spring, Braun has spoken to students at five universities and an inner-city high school in Philadelphia, where he kicked the tires of two hybrid cars the high schoolers had built out of spare parts and gushed, "Maybe you can get a revolution going, of young people around the country doing things like this." Everywhere he goes, Braun—a short, alert man with close-cropped brown hair, dimples, and an easy smile—tells folks to call him Bobby. He even gives out his e-mail address: bobby@nasa.gov. "Pretty easy to remember."

But tweaking the public perception of NASA is just one aspect of his job. Braun is also fighting a battle *within* NASA to change an institutional culture that, at its worst, prefers timid, scientifically unambitious projects to riskier, grander ones. The space shuttle is the classic example. For 30 years, the shuttle—a technological marvel of the 1970s—put food on the table for 1,500 civil servants and more than 10,000 private contractors. It was politically and bureaucratically unkillable, even though each mission cost $450 million and the shuttle astronauts spent their days basically doing victory laps in low-Earth orbit. In 2003, when seven astronauts died in the Columbia explosion and NASA scrambled to come up with a replacement for the shuttle (whose final flight is scheduled for later this year), it decided to build a new ship and a new rocket to go to ... the moon. Last April, President Obama canceled that moon return mission: "I just have to say pretty bluntly here: We've been there before." Obama said he wanted NASA to concentrate on "groundbreaking technologies" that would allow astronauts "to travel farther and faster for less cost."

Braun's vision aligns with Obama's. His office controls about a billion dollars, or 5 percent, of NASA's yearly budget, and he is investing some of that money in what he calls "technology-pull" projects, where the director of a near-term mission asks him for a specific technology to help execute the mission and Braun figures out how to provide it. But Braun's heart is in exploring the opposite path to innovation: "technology-push." That's where, instead of laying out a hard, JFK-like mission goal (America will land a person on Mars within 15 years), you lay out a menu of cool stuff you might want to do—say, identify Earthlike planets around

An inner-city high school in Philadelphia may seem an unlikely place to find NASA's chief technologist, but Braun went there last June to meet a student team whose custom-built hybrid cars were getting 80-plus miles per gallon.

NASA/BILL INGALLS



NASA/CARLA CIOFFI

other stars, or land on an asteroid. Then you identify the menu of technological capabilities required to accomplish those things. Then you give relatively small amounts of money to of a bunch of different people trying a bunch of different things to make those technologies real. It's sort of like sitting down at a restaurant and instead of saying, "Give me the lamb burger," you invite chefs from all over the world to compete to make you the best meal.

A crucial part of Braun's strategy is that about 70 percent of the projects he funds will be selected by competition, in a peer-reviewed process, and instead of only NASA engineers competing, it can be anyone—academics, private contractors, hackers in garages. On human missions, Braun says, "We're not going to do anything crazy or take any huge risk" that would jeopardize astronaut safety, but on smaller projects, especially robotic ones, Braun wants NASA's technology innovators to be energized by risk and comfortable with failure. "You learn just as much from failure," Braun told the high school students in Philadelphia. "If you're not failing, then you're not really reaching for something grand."

The simple fact, Braun says, is that our status-quo technologies—the way we launch vehicles into space, the way we move around once we're in space, the sorts of materials we use to shield the ships from radiation—have reached their upper limit. If we want to go farther, faster, we have to start, in many areas,

Braun (shown here hosting a NASA Town Hall meeting last May) points out that NASA's investments in space technology make a difference in people's everyday lives—from GPS navigation to cleaner energy to better weather forecasting.

from scratch. To take just one example, think about how you would land a ship gently on another planet—Braun's personal engineering specialty. The ship is going maybe 16,600 miles per hour. How do you slow it down? Parachute? Retro thrusters? Heat shield? These techniques work fine for small objects. "The Mars Pathfinder rover I helped land is not much bigger than maybe the printer on your desk," says Braun. The next rover to land on Mars, the Mars Science Laboratory, scheduled for launch this year, is about the size of a small car: one metric ton. But scientists estimate that any ship large enough to carry humans to Mars, burdened by equipment and fuel, could weigh much as *100 metric tons*. Says Braun: "We're talking about being able to land a two-story house on Mars." It would theoretically require a chute as wide as 20 football fields. "Even if you cluster chutes together," Braun says, "it just gets crazy, quick."

There are a few radical ideas in the early stages of testing. One is called supersonic retro-propulsion, a bit of voodoo that involves using retro thrusters early on in the descent, at incredibly high speeds, instead of just at the last minute, when the craft has slowed. Another idea is to deploy something called an inflatable aerodynamic decelerator, or IAD, basically a giant cloth bladder that's stronger than a parachute and can be deployed at a speed that's either hypersonic (greater than Mach 5) or supersonic (Mach 1 to Mach 5). In an August 2009 test flight, researchers at NASA Langley successfully deployed an IAD at a speed of Mach 6.

It's the nature of Braun's job that he can't just push his favorite technologies. He has to be professionally impartial, which is why, in December, his team published a "Space Technology Area Road Map" identifying 14 key areas in which he'd like to see progress. But when you press him, you can tell what really gets him excited. And it's not what you might think. Braun of course has a picture of the Mars Pathfinder landing site from 1997 on the wall, across from a black-and-white photo snapped by Viking 1 in 1976. Braun is a Mars guy. But underlying his interest in Mars is a broader interest in the big questions, "the society-changing questions," that Braun believes we're on the verge of answering. Ask him about the search for Earthlike planets and his grin pushes his dimples into sharp relief. He told an online podcaster in November: "Questions like, Are we alone? Is there life elsewhere in the solar system? Questions like, When I look up at night and see all those stars in the night sky, how many other Earths are up there? And what does that mean, that there may be habitable Earths near other stars?"

Tom Wolfe, chronicler of the Mercury program, once wrote that NASA's biggest mistake was that it failed to realize the importance of explaining *why*. It needed a philosopher. Why invest in bigger telescopes to locate Earthlike planets? Why send humans to asteroids, to Mars? "If we make the right technology investments, we can do these things," Braun says. "In fact, NASA exists to do these things." Maybe the best thing that the chief technologist can do for NASA is to become the philosopher it never had.

"IF YOU'RE NOT FAILING, THEN YOU'RE NOT REALLY REACHING FOR SOMETHING GRAND."

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