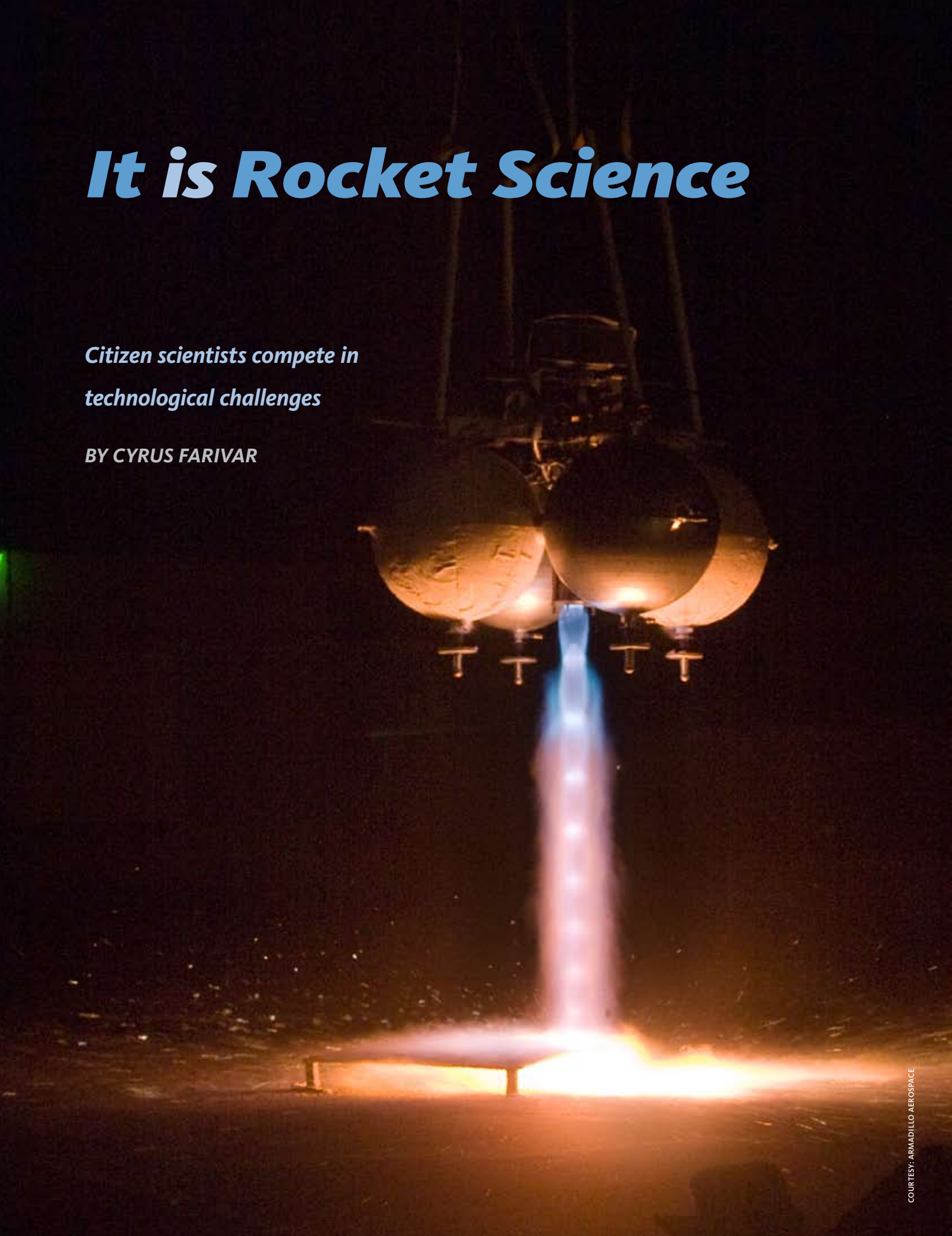
It is Rocket Science

Citizen scientists compete in technological challenges

BY CYRUS FARIVAR



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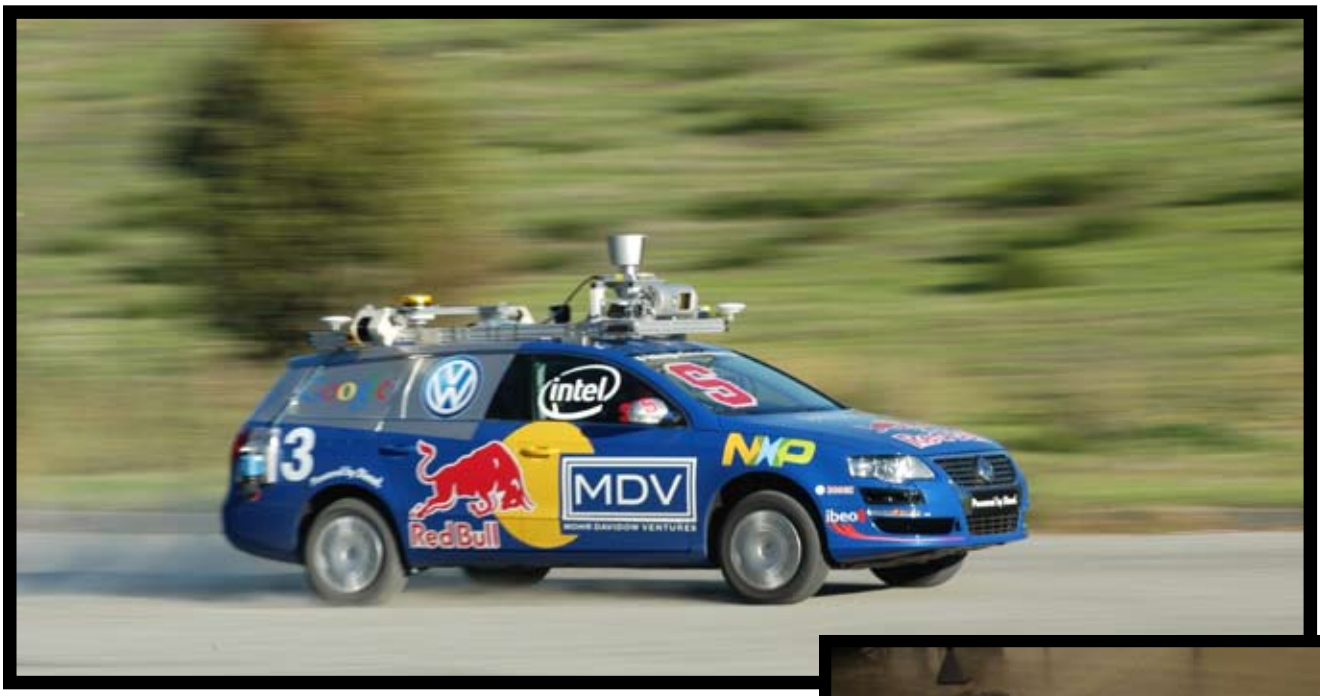
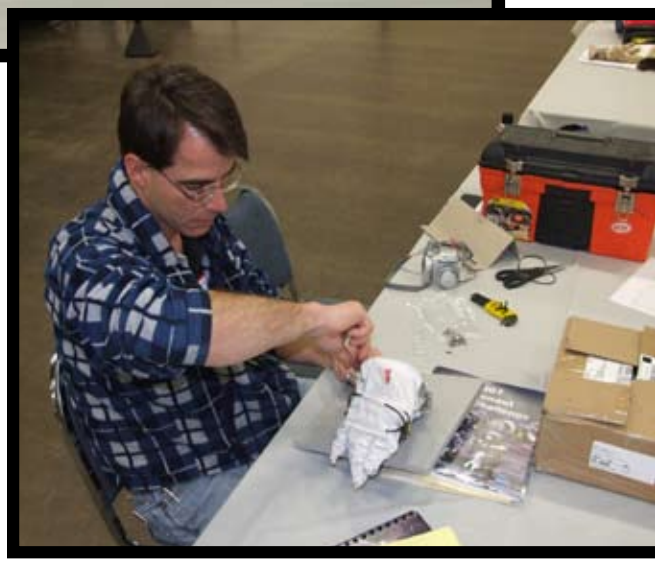


(BELOW) ALAN HAYES / VOLANZ AEROSPACE; (LEFT) COURTESY: DARPA



__LEFT:__ A LUNAR LANDER, THE PIXEL, HOVERS ABOVE GROUND IN A TEST FLIGHT. __TOP:__ STANFORD RACING'S "JUNIOR" WON THE $1 MILLION SECOND PLACE PRIZE IN THE 2007 DARPA URBAN CHALLENGE. __ABOVE:__ PETER HOMER WORKS ON HIS WINNING ASTRONAUT GLOVE.

It was late spring 2007, and Peter Homer was at his dining table, a sewing kit, thread, string and various gloves spread out before him. It was late, and the engineer by training, part-time bus driver by trade, had a job to finish—building an astronaut's glove.

Homer wasn't just building an astronaut's glove for fun—though he was also motivated by his love of science and engineering—he was determined to win NASA's 2007 Astronaut Glove Challenge, and the $200,000 prize that went with it. One day, while browsing the Internet last year, Homer came across NASA's Centennial Challenges Website. There the former satellite designer, who relishes a problem to tackle, discovered the glove competition.

It was an opportunity for home-inventors and public citizens, such as Homer, to make something that would work for a real astronaut, in space. And, work better than the glove NASA had already developed.

"The glove, that's something I could handle in my garage," he says.

For Homer, who lives on an island off the southern coast of Maine, the problem he had to solve for NASA was about dexterity. The gloves that astronauts currently wear tend to be overly stiff, making their work—already complex—even more difficult than it would be on Earth.

Part of the problem with existing gloves is that they must be flexible and rigid simultaneously, Homer explains. "When [the glove is] pressurized, it's like a bicycle tire; it gets very rigid," he says. In fact, he says, astronauts tend to spend a lot of their training trying to figure out how to overcome the limitations of the glove.

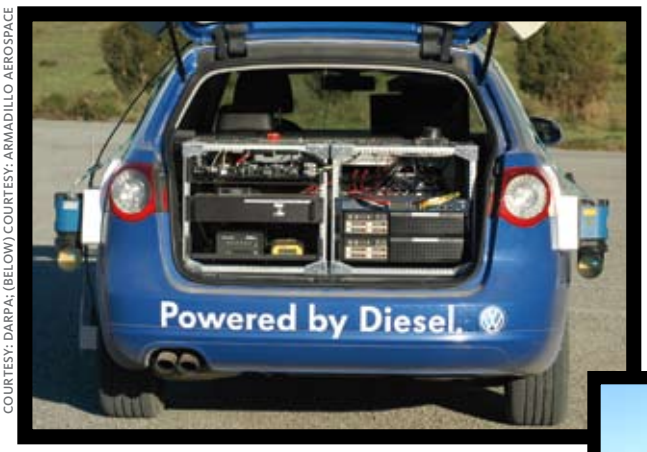
In space, even turning a dial is difficult.

To solve that problem, NASA decided to reach out beyond the space industry for a solution. The Astronaut Glove Challenge is

just one of nearly a dozen such competitions in NASA's prize program, known collectively as Centennial Challenges. The contests are designed to "stimulate innovation and competition in solar system exploration and ongoing NASA mission areas."

They are also meant to encourage the development of innovative technologies from new sources of creativity and ingenuity, says Ken Davidian, program manager of Centennial Challenges. "We're looking outside the NASA family—who else out there has great ideas?"

In 2007 NASA funded six challenges—including the Astronaut Glove Challenge and the Lunar Lander Challenge, a $2 million competition requiring a vehicle to simulate trips between the moon's surface and lunar orbit. Six more competitions are scheduled for 2008.



COURTESY: DARPA; (BELOW) COURTESY: ARMADILLO AEROSPACE

NASA's Centennial Challenges are just a few of the numerous science competitions being hosted by agencies and organizations across the United States. Whether it's a challenge to build a driverless car, launch a rocket into space, land a rover on the moon or develop the 100-mile-per-gallon car, each is designed to find a solution to an unique problem, from uncommon sources outside a highly technical industry. Typically, each of these competitions is open to all comers, be they individuals, amateur engineers, or large entities such as universities and corporations.

Take, for example, the Defense Advanced Research Projects Agency (DARPA) Grand Challenge, hosted by the Department of Defense, a competition to develop an autonomous vehicle that can travel a nearly 150-mile off-road course in the Southern California desert using GPS coordinates to reach its destination. The vehicle must drive and navigate itself to the endpoint, without any interference from the team that created it.

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Why the competition? Having a vehicle the military could send into battle without any direction from its human controllers would be immensely valuable; having people who don't normally do business with the DOD was also an objective.

"[The DARPA Grand Challenge] allowed us to reach out directly to these people and get them involved in an area in national security," says Jan Walker, a spokesperson from DARPA, the Department of Defense's central research organization.

None of the 13 Grand Challenge 2004 teams completed the 142-mile course between Barstow, California and Primm, Nevada. Carnegie Mellon University came closest, completing 7.4 miles.

The 2005 DARPA Grand Challenge saw more success. Competition was stiffer, with 23 university-sponsored and corporate-backed teams participating, and five vehicles successfully completing the 131.6-mile course. In the end, the race came down to teams from Carnegie-Mellon and Stanford University, with Stanford completing the course in six hours, 53 minutes and 58 seconds, to take home the $2 million prize. Carnegie-Mellon's Red Team was about four minutes behind.

ABOVE LEFT: *THE AUTONOMOUS VEHICLE "JUNIOR" SHOWS OFF ITS BRAINS AT THE DARPA URBAN CHALLENGE.* ***ABOVE:*** *A CROWD WATCHES TEAM ARMADILLO AS IT ATTEMPTS TO WIN THE LUNAR LANDER CHALLENGE.*

Giving people in the public sector a goal—such as the DARPA challenge—leads to more output, Walker says. "I don't know if it's an American thing or a human thing, but the idea of having a goal has led to much larger return on investment than we would have gotten if we had awarded contracts."

Which may be why this year, DARPA upped the ante and recently began sponsoring the Urban Challenge. The race is similar to its predecessor the Grand Challenge—both require cars to be completely autonomous—but instead of being held in the desert, the vehicles must travel on a 60-mile course in a simulated urban environment—an abandoned Air Force base outside of Victorville, California.

This challenge is much tougher: Each car has to obey all California traffic laws, and dealing with other cars in motion—merging in and out of traffic, for instance—is tricky to engineer. Not impossible, however. In November, DARPA awarded the $2 million first-place prize to Tartan Racing of Pittsburgh—an alliance of Carnegie Mellon University, General Motors Corporation and others—and a $1 million second-place price to Stanford Racing's "Junior".

Many of these modern science competitions take their inspiration from the Orteig prize, won by Charles Lindbergh.

In 1912, hotel owner Raymond Orteig moved to the United States from France. Seven years later he put up $25,000—equivilant to about $300,000 today—for the first person to fly nonstop from New York to Paris or vice versa. It wasn't until 1927 that the strapping 25-year-old man from the Midwest achieved the historic flight, completing the journey in 33 hours, and collecting the prize. Overnight, modern intercontinental flight was born.

In the contemporary era, prize-based competitions truly began in 2004. There was the DARPA Grand Challenge, and Congress' gift to NASA: $12 million for its Centennial Challenges contest budget, the vast majority of which is still up for grabs. At $200,000, the prize for the glove competition is among the smaller

COURTESY: ARMADILLO AEROSPACE

ABOVE: *THE ALL-VOLUNTEER TEAM ARMADILLO CELEBRATES A SUCCESSFUL LUNAR LANDER FLIGHT.*

awards; $2 million will be awarded for creating a lunar lander.

There was also the X Prize Foundation's Ansari X Prize, a challenge for a nongovernmental organization to launch a reusable, manned craft into space. The first team to do so twice within two weeks would receive a $10 million prize.

Given that only a handful of government-backed ventures have achieved spaceflight, the idea was to kick-start the privatization of the spaceflight industry. In October of 2004, the prize was awarded to SpaceShipOne, built by aerospace designer Burt Rutan and financed by Microsoft co-founder Paul Allen.

For the foundation which creates and manages awards for innovation in order to "bring about radical breakthroughs for the benefit of humanity" it's all about revolution through competition.

In addition to the spacecraft challenge, the X Prize Foundation, which was founded by Dr. Peter H. Diamandis, has developed other prizes to help spur research in fields that push the limits of current science. There are prizes in genomics and lunar exploration. Then, there's the prize that may have the most immediate impact on everyday consumers: the Automotive X Prize—AXP.

The premise of AXP is to build a "production-capable" car that will exceed 100 miles per gallon, or its equivalent in terms of energy efficiency, and win a series of road tests. That means the cars could be electric, hybrid, gasoline, or some other unforeseen combination. The important thing is that the cars actually work, and that they're commercially feasible. Teams must even present a viable business plan for bringing their vehicles to market.

"PRIZE COMPETITIONS ARE GREAT. THAT'S WHY LINDBERGH FLEW ACROSS THE ATLANTIC."

"We make a distinction between the cars that you read about and see on the covers of magazines and the cars that you see on showroom floors," says Don Foley, executive director of the Automotive X Prize. "We want to demonstrate that they're not just science projects."

The fuel-efficiency benchmark of 100 miles per gallon, if achieved, would more than double the current standard: The Toyota Prius, currently the most fuel-efficient car on the market, gets 48 miles per gallon on city streets and 45 miles per gallon on the highway, according to the 2008 Environmental Protection Agency and Department of Energy's fuel-economy guidebook.

Though the amount the AXP will award hasn't been announced yet—Foley says that it will be at least $10 million—40 teams worldwide have submitted a letter of intent to compete.

Foley expects the cars will be ready for testing by the latter half of 2009. There will be several qualification rounds, culminating in a public point-to-point race between major cities, for example, between Seattle and Portland. The cars will have to meet current safety and emissions standards. The races will test speed and time.

The X Prize Foundation has two other competitions currently: the Archon X Prize for Genomics and the Google Lunar X Prize. The Archon prize, which was announced in late 2006, will award $10 million to the first team that can sequence 100 human genomes in 10 days, at a cost of no more than $10,000 per genome, or $10 million. Its goal is to beat the current benchmark of sequencing a single human genome in nine months at a cost of $300 million. The hope is that reducing the cost of mapping out a human genome will result in more affordable genetically-based treatments of inherited ailments.

Announced this fall, the Lunar X Prize is being co-sponsored by Google. Anyone in the world can compete for the $20 million grand prize, which can be won by putting—within the next seven years—a functioning, roaming, broadcasting lander on the surface of the moon. The rover has to get to the moon safely, land, broadcast a report back to Earth, move 500 meters, and broadcast what it sees again.

Also, at each step of the way, entrants will have to document—online—the various steps of their progress, posting photos and blog entries, chronicling their progress so that fans can follow along. Allowing the public to follow along as the lander is built is meant to demystify what goes into building a spacegoing vehicle.

"It's about near-real-time video coming back from the moon, enabling lower-cost exploration of the moon, and public participation such that we have a paradigm shift in the exploration of space," says Bretton Alexander, the executive director of the Lunar X Prize.

Alexander points out that while the task of landing on the moon has already been achieved, by bringing it back into the focus of the public—

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particularly among high school and college students who are considering careers in engineering—prize competitions can hopefully spark some new life into such fields as aeronautical and astronomical engineering.

"We're taking it out of the realm of governments being able to do these sorts of things and making it accessible to a lot more people, which will ultimately benefit all of us," says Alexander.

Including citizen scientists such as Homer. In the spring of 2007, he was re-evaluating his entire approach to the astronaut glove problem. His early designs simply weren't working, and weren't likely to pass the dexterity tests. The competition deadline was weeks away.

The real problem, he decided, was how to make a more flexible finger—something that's easier to bend. "So the approach I took was to not build gloves, but to build fingers," he says. "I built dozens of fingers. I could pressurize them and bend them and see whether or not I was on to something."

One after another, fingers were constructed—30 in all; 29 of them didn't work, but one did.

"The epiphany came when I was wrapping tape around my finger and trying to come up with a way to create an articulation," he explains.

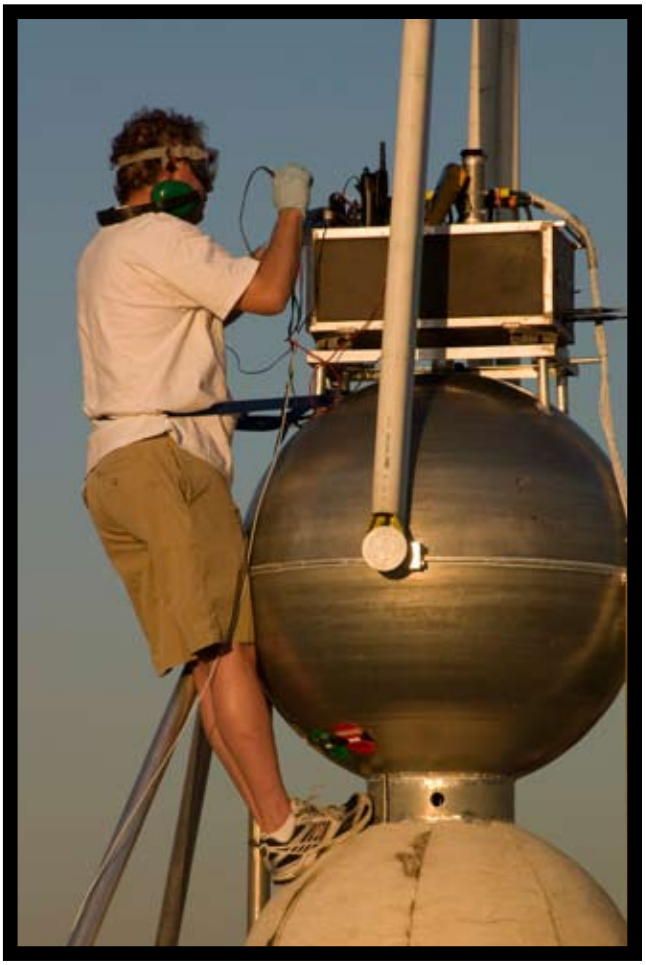
Late one night, with the clock ticking, adrenaline pumping, and his wife and children sound asleep, Homer sat at his dining room table, staring at his hand while wrapping painter's tape around it. On a whim, he tried arranging the tape so it made an X pattern—a criss-cross. It worked: He could close his hand in a fist or open it up wide.

"Then it was a matter of figuring out how to recreate that into this fabric structure that's designed to pressurize gas. Once I had the finger, it was then taking that same concepts into the thumb and wrist and the rest of the glove."

In other words, by reducing the problem down to its most basic component—the fingers—he could build the rest of the glove out from there.

What Homer didn't know was whether his brainstorm would be enough to defeat the other gloves at the New England Air Museum, where the competition was held in June. As he raced through the final weeks, he wasn't sure if his efforts to go from making criss-crossed fingers, to knuckles, joints and the wrist, would hold up to competitive scrutiny.

Whether he was the only competitor or one of 100 didn't matter. "I really wanted to beat the house glove," he says, referring to



COURTESY: ARMADILLO AEROSPACE

ABOVE: *FIXING A LANDER DURING THE 2007 NORTHROP GRUMMAN LUNAR LANDER CHALLENGE.*

NASA's current model, the Mark VI.

As it turns out, finger-by-finger was the solution. All of those nights staying up late, learning more about finger torque than he ever dreamed of, paid off. In June, Homer beat the house glove and bested four other competitors to win the purse.

The first thing that he spent his winnings on was a previously canceled Disney-theme cruise for his wife and kids. And NASA tossed in some tickets to see a space shuttle launch at the Kennedy Space Center in Orlando, Florida.

Without the $200,000 enticement, Homer admits that he wouldn't have built the glove, much less become well-known in the small world of people who care about astronaut gloves.

"Prize competitions are great," Homer enthuses. "That's why Lindbergh flew across the Atlantic." ▲

Cyrus Farivar writes about technology from his home in Oakland, California.