A VISIT TO OUR STAR

The upcoming Parker Solar Probe will take NASA closer to the sun than ever before

Matt Alderton
Special for USA TODAY

If you studied Greek mythology in school, you probably remember the story of Icarus. He and his father, a master craftsman who had built the Labyrinth to hold the Minotaur, were imprisoned in a tall tower. His father fashioned wings for them out of bird feathers and wax. Before they took flight, Icarus' father warned him not to fly too close to the sun, lest the heat melt the wax and destroy his wings.

Like so many sons, Icarus ig-

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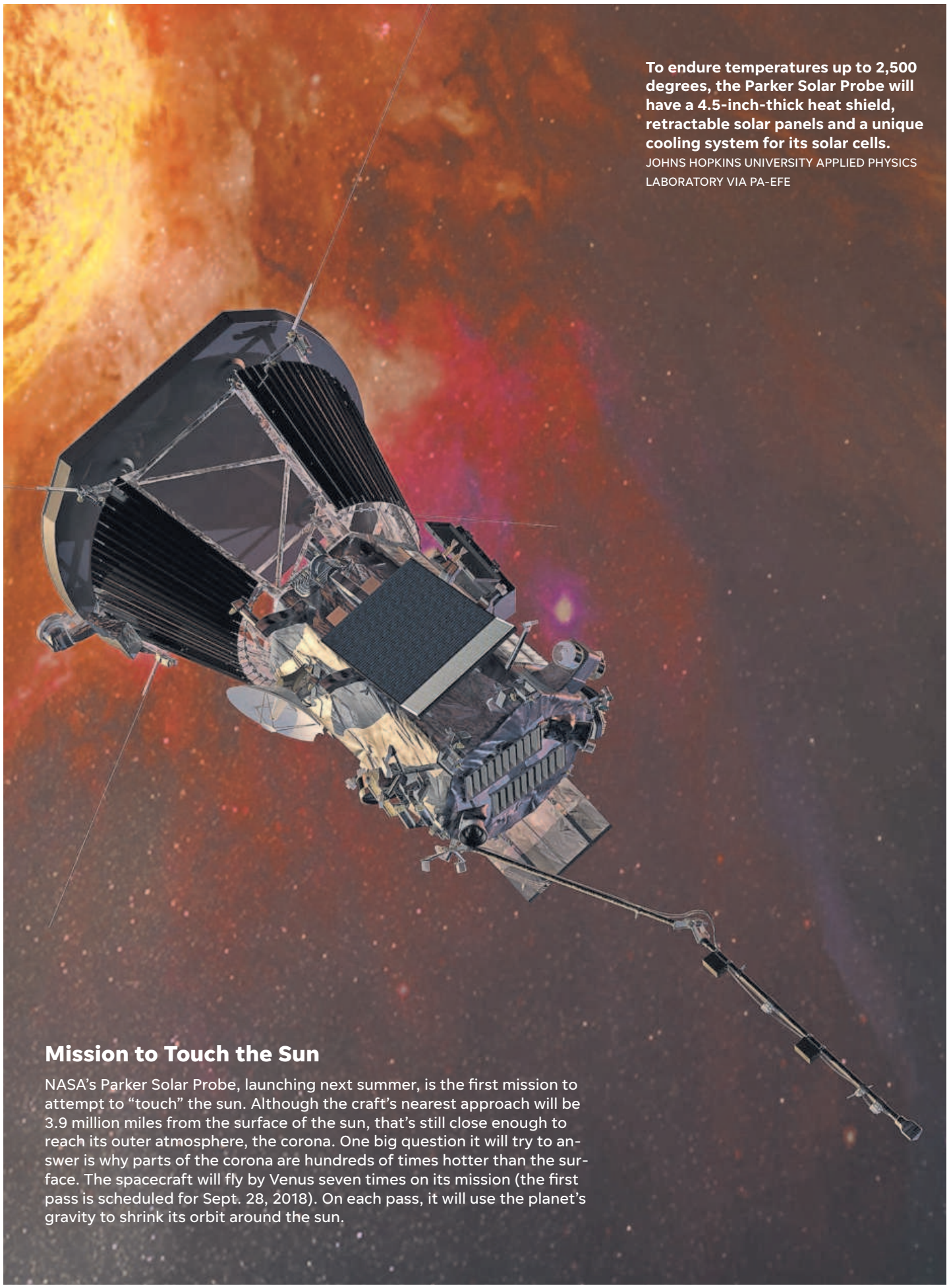
A blast of radiation known as a solar flare extends into space in an image captured by NASA's Solar Dynamics Observatory in March 2016. NASA VIA EUROPEAN PRESSPHOTO AGENCY



To endure temperatures up to 2,500 degrees, the Parker Solar Probe will have a 4.5-inch-thick heat shield, retractable solar panels and a unique cooling system for its solar cells.
JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY VIA PA-EFE

Mission to Touch the Sun

NASA's Parker Solar Probe, launching next summer, is the first mission to attempt to "touch" the sun. Although the craft's nearest approach will be 3.9 million miles from the surface of the sun, that's still close enough to reach its outer atmosphere, the corona. One big question it will try to answer is why parts of the corona are hundreds of times hotter than the surface. The spacecraft will fly by Venus seven times on its mission (the first pass is scheduled for Sept. 28, 2018). On each pass, it will use the planet's gravity to shrink its orbit around the sun.

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nored his father's advice. Emboldened by the feeling of flight, he flew higher and higher until his wings disintegrated, sending him plunging into the sea below, a victim of his own hubris.

As NASA prepares to launch its first-ever mission to "touch" the sun in 2018, one can't help but think of Icarus and wonder: Can it take the heat?

Nicky Fox says it can. Project scientist for NASA's $1.5 billion Parker Solar Probe mission, she's one of thousands of scientists and engineers over the past six decades to have dedicated themselves to designing and building a sun-resistant spacecraft. Once a pipe dream, that spacecraft is now less than a year away from its scheduled launch at Kennedy Space Center in Florida.

"The mission itself predates NASA," says Fox, a space weather and applied physics scientist at the Johns Hopkins University Applied Physics Laboratory in Laurel, Md., which is designing and building the Parker Solar Probe and will operate it on NASA's behalf. When Congress created NASA in 1958, she says, it did so with 12 original missions in mind. One of those was building a solar probe capable of penetrating and analyzing the sun's outer atmosphere, known as the corona. "Of those 12 missions, the only one that has not yet flown in any form is the solar probe, and that's because we've never had the technology or budget at our disposal to be able to send a spacecraft right into the corona. Now we do."

Named for astrophysicist Eugene Parker, who discovered the phenomenon of solar wind — a stream of charged particles that emanates from the sun and permeates the solar system — the Parker Solar Probe will launch next summer. The launch will commence an initial six-week journey toward Venus, which it will fly past seven times during its seven-year mission. On each pass, it will use Venus's gravity to gradually reduce the size of its orbit around the sun, ultimately bringing the probe to within 3.9 million miles of the sun. By comparison, Earth is 93 million miles from the sun, and Mercury — the closest planet to the sun — is 29 million to 43 million miles out, depending on where it is in its elliptical orbit.

"It may sound like a far distance, but the closest we've ever gotten to the sun was the Helios mission (in the 1970s), which got to about 27 million miles," says Parker Solar Probe program executive Joseph Smith. "This time, we're going to get within 4 million miles of the sun. To me, that's groundbreaking."

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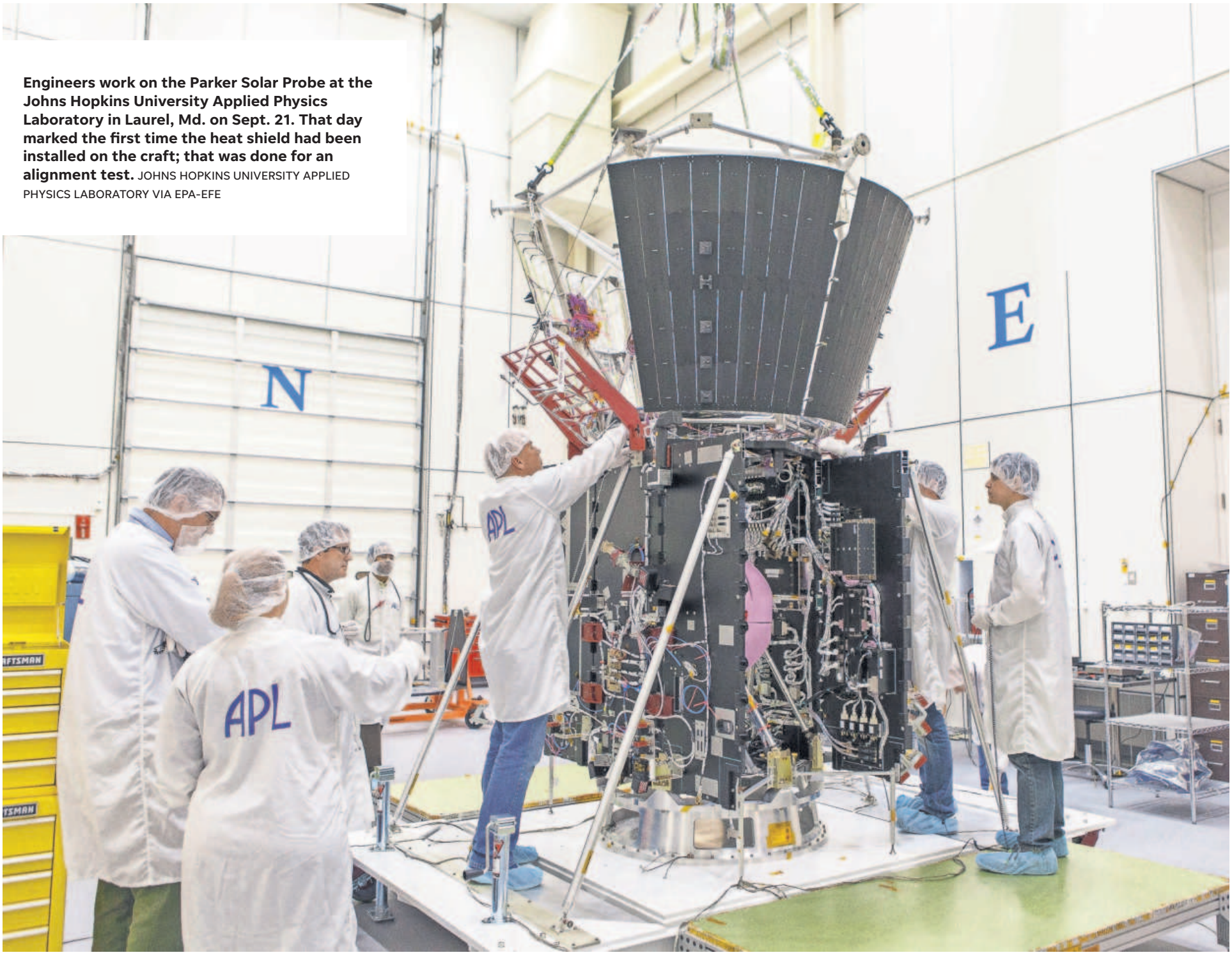

Engineers work on the Parker Solar Probe at the Johns Hopkins University Applied Physics Laboratory in Laurel, Md. on Sept. 21. That day marked the first time the heat shield had been installed on the craft; that was done for an alignment test. JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY VIA EPA-EFE

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Solving Solar Secrets

People have always been fascinated by the sun. Some of them have even worshiped it — the ancient Egyptians and Aztecs, for example. And for good reason: Without the sun's light and warmth, life as we know on it Earth would not exist.

Heliophilia isn't just a relic of past cultures, however. It's a contemporary phenomenon as well, as evidenced by the solar eclipse that captivated millions of Americans as it swept across the USA on Aug. 21. Not because of the mythology and folklore that have always surrounded the sun, but because of the many unanswered scientific questions humanity still has about it.

Consider, for instance, the temperature of the corona: The sun's outer atmosphere is approximately 3.5 million degrees Fahrenheit, but its photosphere — its visible surface — is just 10,000 degrees Fahrenheit.

"You've got this large heat source, and it gets hotter as you move away from it. It breaks the laws of nature," Fox says. "That is the No. 1 mystery we want to solve."

The No. 2 mystery is how "coronal mass ejections" are created. "The plasma in the corona doesn't just get superheated; it also gets incredibly energized, such that it can escape from the pull of the sun," Fox says. "The sun is the biggest thing in our solar system. It's a huge gravitational body and it's very, very magnetic. And yet, somehow, the plasma becomes so energized that it can move away from the sun. It's like hitting the gas and *boom* — it takes off."

Understanding the physics of the corona and how it creates these solar explosions could help scientists better understand and forecast space weather — like the "Carrington Event" of 1859, the biggest solar storm on record. In that event, debris from a coronal mass ejection interrupted telegraph communications on Earth.

"Now that we're so dependent on

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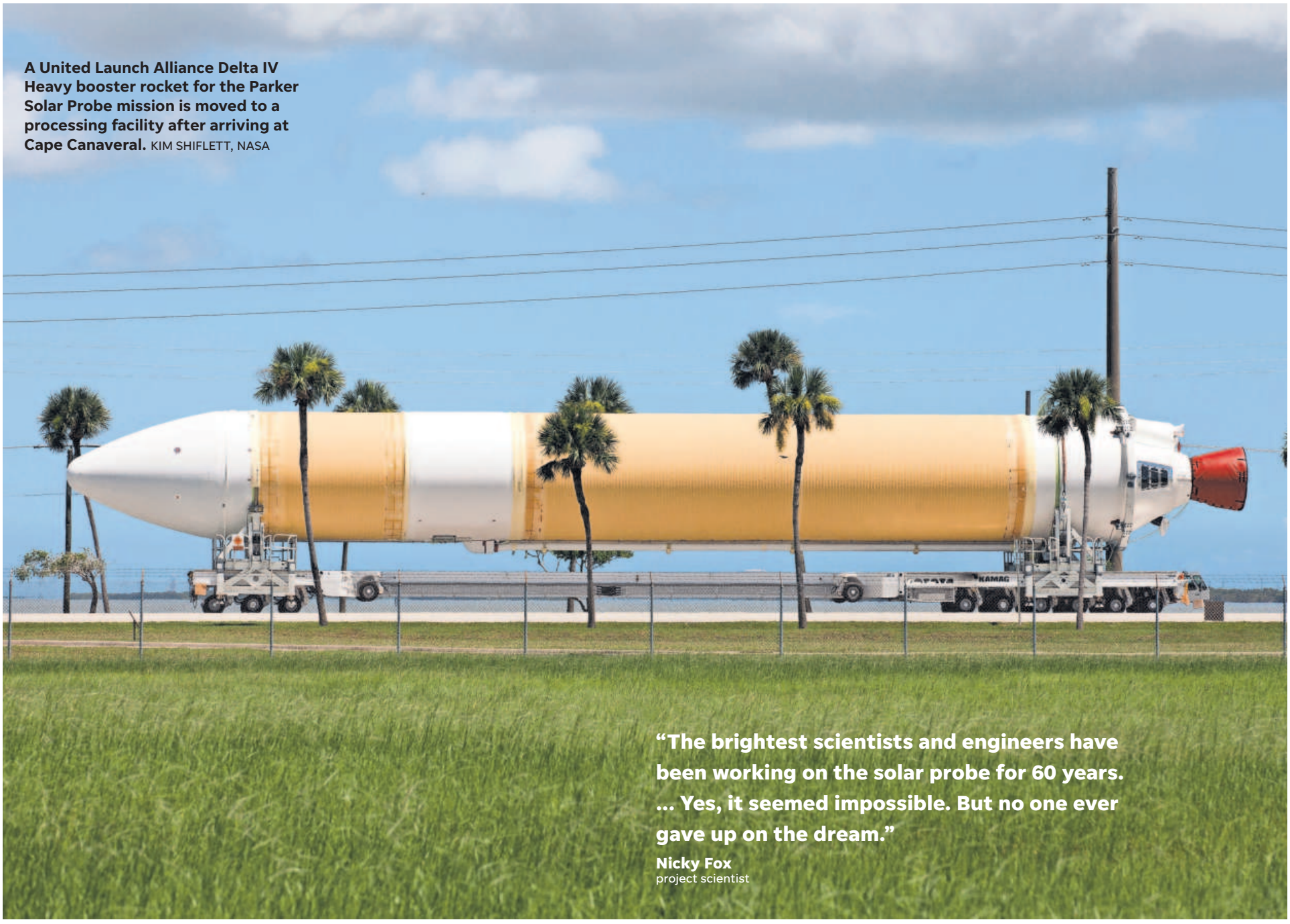

A United Launch Alliance Delta IV Heavy booster rocket for the Parker Solar Probe mission is moved to a processing facility after arriving at Cape Canaveral. KIM SHIFLETT, NASA

"The brightest scientists and engineers have been working on the solar probe for 60 years. ... Yes, it seemed impossible. But no one ever gave up on the dream."

Nicky Fox
project scientist

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technology, if we had a coronal mass ejection of that size today it could be really, really disruptive," explains Smith, who says a solar superstorm could take down electrical grids, satellite communications and GPS. "Being able to predict when that might occur — and being able to put safeguards in place — is very important."

A Technical Triumph

The Parker Solar Probe will attempt to satisfy NASA's coronal curiosity during 24 orbits around the sun, during which it will be exposed to temperatures as high as 2,500 degrees Fahrenheit.

Ensuring the conical spacecraft can withstand the blistering heat is the mission's greatest challenge. The solution: an 8-foot-wide, 4.5-inch-thick heat shield made of a carbon-carbon composite that Fox likens to the graphite epoxy used in golf clubs, bicycles and bone replacements. Coated with a white "plasma spray" that deflects sunlight, it will insulate the scientific instruments inside the probe so they operate at roughly room temperature. Those instruments include sensors to measure the sun's magnetic fields, plasma and energetic particles, and telescopes to get images of the solar wind.

Also needing protection from the sun's heat are the solar panels the spacecraft will use to collect and store energy for its marathon journey. Those panels will have a special cooling system that distributes water through solar cells like blood through veins. The panels will be fully extended when the probe is farthest from the sun, then fold inward when it's closest to it, concealing all but a thin sliver so the solar panels don't melt. At that point, the sun's energy will be so strong that just a few solar cells can generate the same amount of power as the whole array when it's closest to Earth.

"It's only been since about 2005 that we've had the technology to make all this happen," Smith says. "This in no way is a routine mission."

Clearly, the challenges have been great. The rewards, however, will be even greater, Smith says.

"The next time we have an eclipse transit the United States in 2024, we'll be six years into our mission," he says, adding that NASA's investment in the Parker Solar Probe will "pay back in spades."

"We're going to know so much more about the corona then than we do now. It's going to be phenomenal."

And for some people, emotional. "The brightest scientists and engineers have been working on the solar probe for 60 years," Fox says. "Yes, it's hard. Yes, it seemed impossible. But no one ever gave up on the dream to do this mission."