The Parker Solar Probe—Aiming For and Touching the Stars

It is the twelfth of August, 2018. On an isolated launchpad in Cape Canaveral Space Force, the gigantic Delta IV Heavy launch vehicle stands conscientiously, in the final moments before its magnificent ascent towards the atmosphere and out of the bounds of Earth's gravitational field. Its payload is now hailed as the most remarkable breakthrough of space science. It has been creating history ever since, including the most recent news of it "touching" the Sun, the persistent star around which the solar system thrives, a first for a human-made object throughout history.

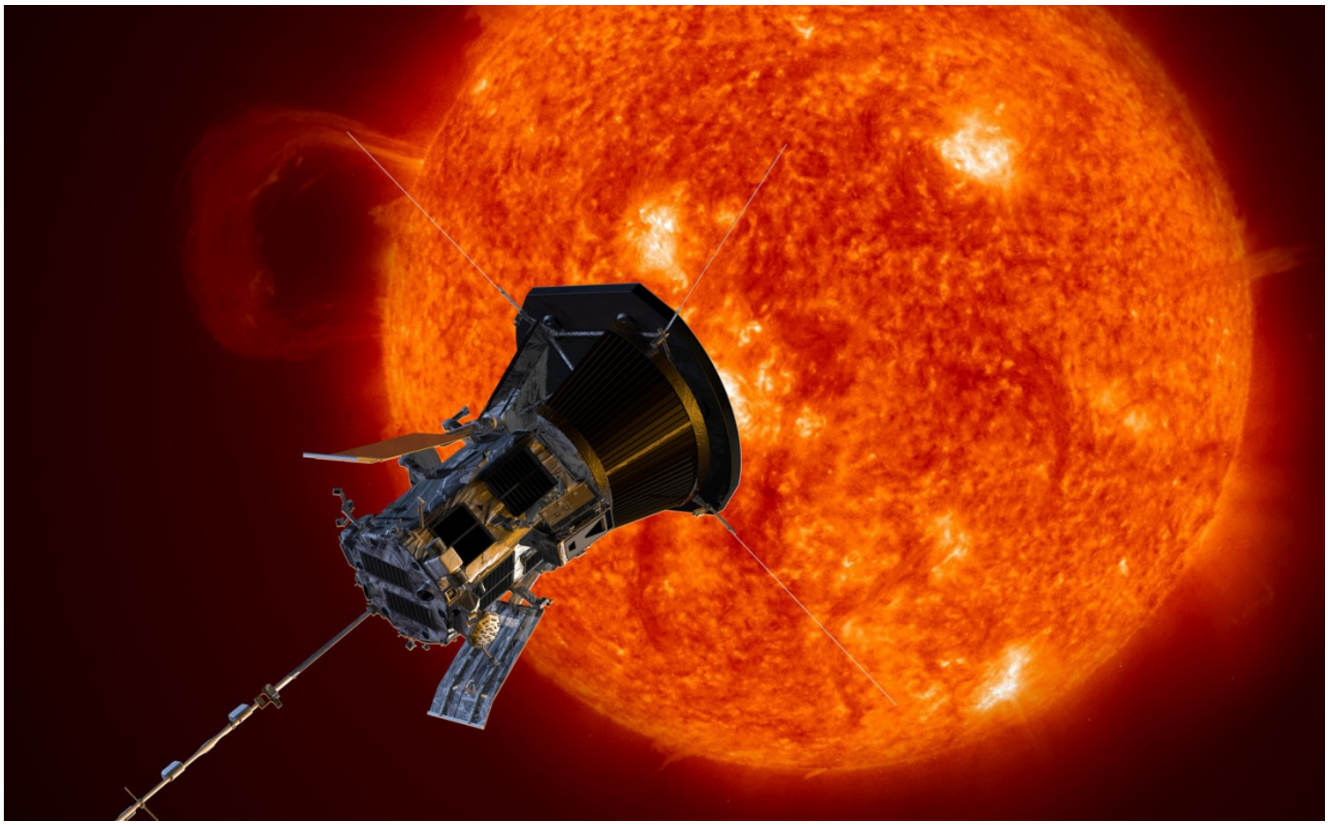
The Delta IV Heavy launch vehicle takes off [Image Credits: NASA]

What is the Parker Solar Probe?

The Parker Solar Probe is a space probe launched by NASA in

2018 with the primary objective of deepening our understanding of the Sun. It helps in transmitting instrumental measurements and discovering the fundamental principle behind the heating of the corona. It also examines the acceleration of solar wind and other energetic particles. The PSP created history by plunging directly into the corona of the Sun, hence touching its first layer and bringing a sci-fi saga to life.

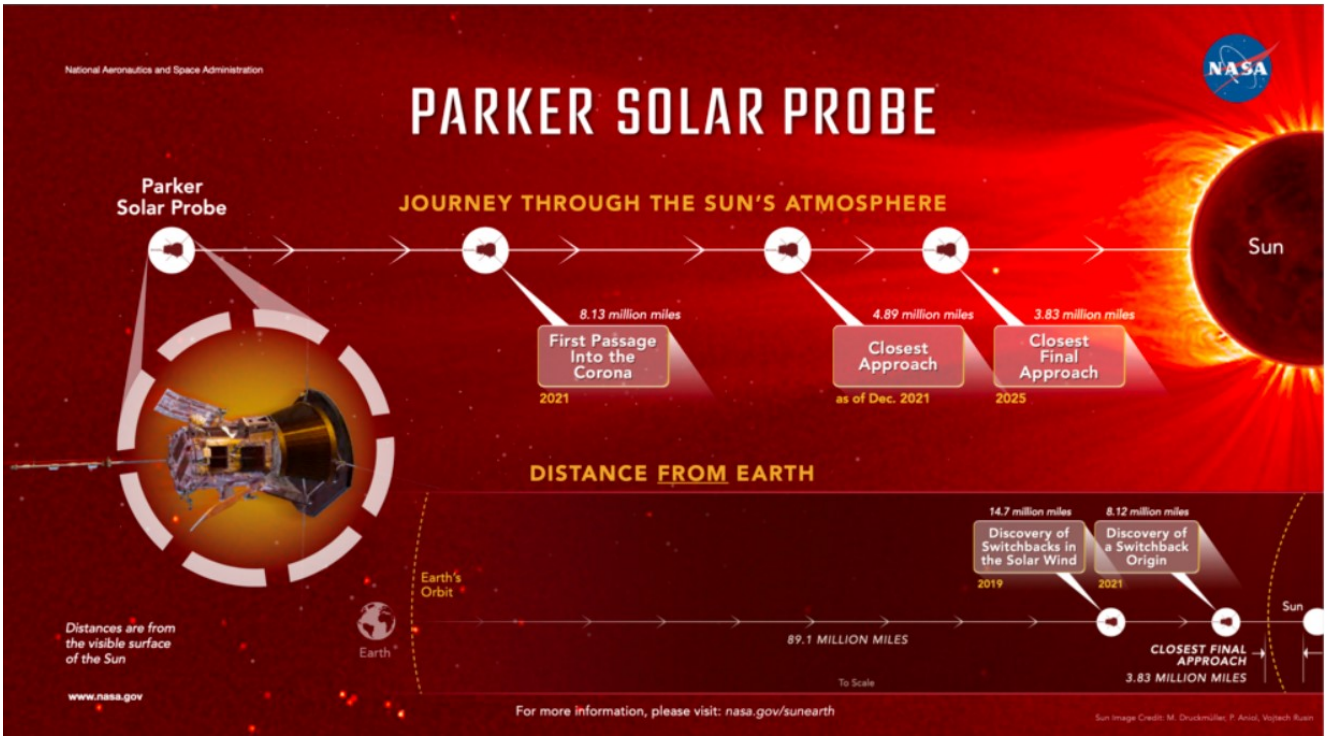
The Probe was named after Eugene Newman Parker, who was unofficially considered the father of solar physics. The first astrophysicist to theorize and model solar wind and nanoflares, Parker, gave us an understanding of the occasional fluctuations caused in satellites and other communication equipment and the occurrence of geomagnetic storms. He also explained the protection routinely provided by a magnetosphere from supersonic particles ejected by the very same layer the Parker Solar Probe dove into, exhibiting warrior-like bravery.



A speculative image showing the Parker Solar Probe around the Sun [Image Credits: NASA]

The idea of a probe to study the Sun's inner layers was first proposed in 1958 by the National Academy of Sciences' Space Science Board. In the subsequent decades, this idea remained in the shadows, as other space adventures were brought under the spotlight. The mention of such a mission resurfaced much later in the 1990s. A concept was proposed for a gravity assist around Jupiter, followed by ejection towards the Sun. This was named the *Solar Probe*, which had unfortunately been cancelled back then due to budget negotiations.

The 2010s were kinder to this space quest. NASA incorporated the *Solar Probe* into a much more cost-effective version called the *Solar Probe Plus,* which used Venus gravity assists. They were deemed short enough to be powered by solar panels and could thus reduce the strain on the thermal protection system. This was further renamed the Parker Solar Probe in honour of the scientist who first predicted the phenomena for which this Probe was designed and supposed to conduct scientific investigations.

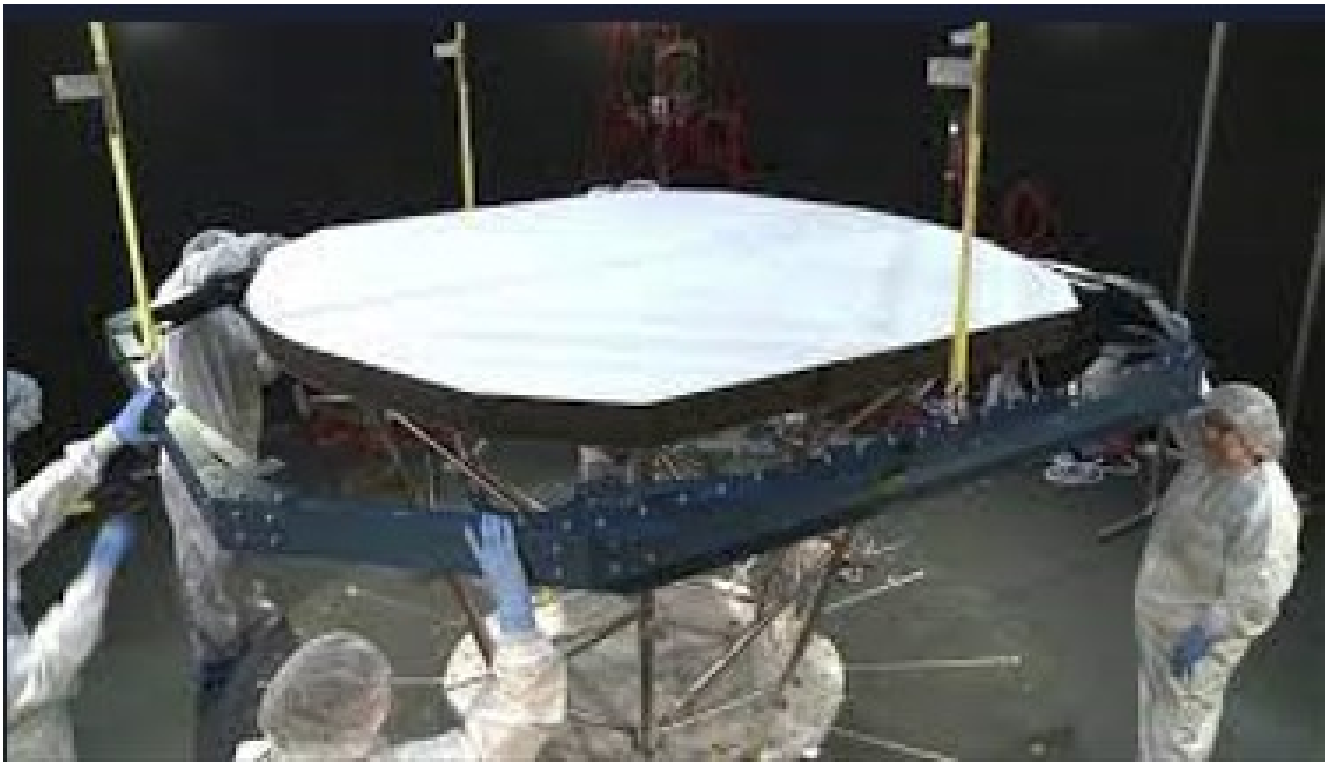


The Parker Solar Probe's highlights throughout its journey [Image Credits: NASA]

Recipe for a Machine Entering a Star

Apart from the mission details and objectives, some intriguing aspects of the Parker Solar Probe are the design and engineering marvels that go into building it. An excellent point to note is the necessity to develop a mechanism to keep the Probe from melting due to extremely high temperatures (the corona of the Sun can heat up to 1,000,000 kelvin) while keeping the internal systems at optimum temperatures to ensure the robust working of the scientific equipment on board. Further, the Sun's inner coronal layers consist of hypothesized supersonic dust particles and 'micro meteors', which are fragments of comets or other space objects disintegrated in the Sun. Other such debris posed colossal threats to the Probe and the security of its equipment on its long journey towards the Sun.

The engineering involved in building the Parker Solar Probe is indisputable and beyond the virtuosity of the annals of space, aerospace, and engineering. Since the Delta IV Heavy launch vehicle has limited payload capacity (irrespective of holding the designation of the second most powerful operational launch vehicle in the world in terms of payload capacity), the Probe needs a very durable and resilient protection system—the thermal protection system (TPS) provides just the right degree of protection. It is a composite heat shield made of carbon-reinforced sheets sandwiched between each other with resins pre-dried till 3000 degrees Fahrenheit after each layer. This is done to eliminate the risk of the resins evaporating, thus shaving off unnecessary weight and resulting in enough heat capacity to withstand temperatures close to 2500 degrees Fahrenheit.



The probe's thermal protection system enters thermal vacuum testing [Image Credits: JHU Applied Physics Laboratory]

The solar panels are the power supply system of this Probe. Since the Probe needs a constant source of power to keep the internal hardware operational, the need for solar panels is obvious. However, the solar panels are rated to withstand only up to certain temperatures. Any further increment would disintegrate them. Near the Sun, 1 W of electricity produces 13 W of heat. Hence, unlike conventional solar panels that are built on an aluminium or honeycomb composite base, the discussions on Parker Solar Probe are made on a Titanium platen with microtubes running through it. These microtubes circulate the coolant back to the pump, and the generated heat is then radiated into space. Interestingly, deionized and high-pressure water is being used as a coolant for such a probe mission. The solar panels are built to retract and expand into the body of the Probe, and only a tiny proportion is angled outwards to provide a sufficient amount of power for the system and prevent material damage. Hence, through a very rigid carbon fibre-based heat shield and a high-pressure water-based microtubular cooling system, the Parker Solar

Probe is thus able to withstand extreme temperatures during its mission lifespan near Sun’s close quarters.

It also has a Kevlar-composed Micrometeorite Protection System, protecting the Probe from any debris striking its body and damaging its components. Generally, spacecraft do have a micrometeorite protection system, but the remaining elements of their systems are much simpler compared to a probe meant to be close to the Sun. It is hypothesized that dust particles move at extremely high speeds at close distances to the Sun. Hence, the Kevlar shield protecting the Parker Solar Probe is purpose-built with this hypothesis in mind, with a blanket layer to protect internal rupture of systems within the probe.

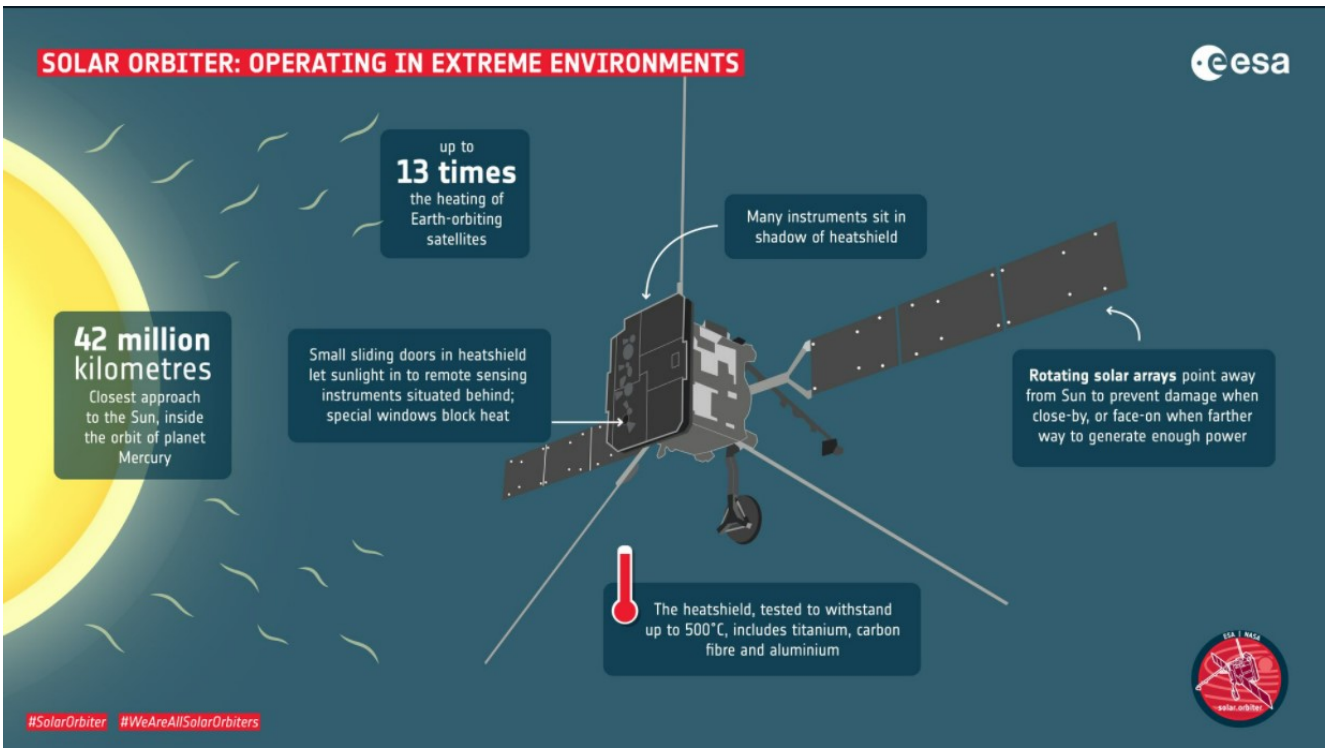
The Parker Solar Probe with its heat shield, solar array, and Kevlar-composed Micrometeorite Protection System under testing [Image Credits: NASA]

The creation of these systems took NASA more than a couple of decades. Finally, they were successfully incorporated into the PSP to create the ultimate machine required for an extraordinarily daring mission.

Future Implications and Significance

The Parker Solar Probe can be adjudged as the luminosity of humankind touching the radiance of our survival. With it breaking all-time spacecraft speed records and plunging into the Sun, it has been enormously useful in confirming previous hypotheses like switchbacks, layers of no clouds of dust in the solar atmosphere, magnetic field intensities in and around the Sun, and other such significant scientific paragon of utmost inquisitiveness. Old myths are being demystified, and new prospects and frontiers of solar physics are being discovered each time it plunges into the star. The Probe has proven to be a treasure trove for scientists and researchers. The probe has been instrumental in discovering that the boundary through which it descended into the Corona was not smooth, as hypothesized, and was uneven and wrinkled, giving the impression of a rugged hilly road during its dives.

It is a possibility that this mission may inspire future missions to the Sun with broader possibilities now that an actual probe has paid a visit to our very own star. Hence, there is always an opportunity to learn from the shortcomings of such novel systems and improve multiple aspects of the same for future missions. Additionally, the engineering supporting the Probe could be used to complement other celestial missions with modifications, or even on Earth, should the need arise.



[Image Credits: The European Space Agency]

Human beings tend to look through the polariser when it comes to the rivalry among countries for winning the title of the sole superpower of the planet. While the probe is not—and never was—meant to be a tool for exaggerating an already aggravating space race, it does create an inferiority complex for countries with a significant space presence like Russia or China. Roscosmos' Coronas Programme acted mostly as a long-distance observation mission, marred with failure, and China launched its first-ever Solar Mission in the form of a telescope. A probe "touching the sun" and reaching its vicinity clearly signifies a proto-diplomatic stance of the "American Might". When coupled with the enriched experience that NASA has from its previous solar missions, the USA clearly seems to be taking the lead. However, with the abundant proliferation of science and innovation across the world and the presence of great minds everywhere, tapping into their potential for space missions would prove to be fruitful for any country.

"*Curiosity is the essence of our existence*," said Gene Cernan, and the Parker Solar Probe fervently asserts that. Many

generations have been enthused by such human endeavours to aim beyond the stars. With the unremitting curiosity of humankind touching the stars, the 21st century seems to be the perfect era to give wings to the New Space Age of humanity.