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Solar System Exploration including Ocean Worlds (5)

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KEYNOTE: EXECUTION OF PARKER SOLAR PROBE'S UNPRECEDENTED FLIGHT TO THE SUN AND EARLY RESULTS

Abstract

Parker Solar Probe (PSP) was launched on August 12, 2018, on its way to enter the solar corona

and "touch" the Sun. It is the first probe to the sun and initial planning for such a probe began six decades ago. Flying a probe to our own star faces unprecedented technical challenges as compared to any other space mission whose destination is a planet, an asteroid, or a comet. In order to approach the Sun, nearly all the orbital speed possessed by the Earth orbit must be removed, which is unachievable even with the most powerful rocket. The PSP mission is designed to launch with the largest rocket available, a customized three-stage launch system consisting of a Delta IV Heavy launch vehicle and a Star-48BV solid upper stage. In addition, we must utilize enormous planetary gravity assists from 7 repeated Venus flybys via a V7GA trajectory in 24 solar orbits over 7 years, in order to get within 8.86 solar radii from the Sun's surface.

To carry out the designed mission and successfully deliver PSP to near the Sun is not trivial. First, the orbit control is much more challenging than usual and requires precise targeting of the 7 Venus flybys at unusually high flyby speeds; while the orbit itself is highly dynamic, non-linear, and subject to significant solar radiation pressure and perturbations of numerous other non-gravitational forces. Second, the extra spacecraft protection and operational constraints made in order for the spacecraft to survive and function in the Sun's harsh environment make the flight operations more complex. In this paper, the overall strategy and plan for PSP's flight execution concerning the in-flight trajectory control and re-optimization, orbit determination and navigation, and trajectory correction maneuvers will be presented. The performance of PSP's launch and initial flight, including the first Venus flyby and first solar encounter, will be reported.

With a high launch C3 (152.222 km2/s2), PSP was injected into the Earth departure orbit with launch error under 1-σ from the launch target. The probe entered the desired V7GA trajectory after a decisive trajectory correction maneuver on August 20, 2018, and made the first Venus gravity-assist flyby on October 3, 2018, only 52 days after departing the Earth. On the 87th day after launch, PSP flew by the Sun at a perihelion distance of 0.167 AU, setting new records as the closest craft to the Sun and the fastest manmade object.