

## Solar Probe Plus: Primary and Backup Launch Windows

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Sun, the most challenging destination to reach technically, will soon be explored with the launch of the Solar Probe Plus (SPP) mission which is currently in the final development stage of integration and testing of the spacecraft and instruments.

The primary launch window of the SPP mission opens on July 31, 2018. There are 20 days of baseline launch period from July 31 through August 19, 2018. The baseline launch period is selected as a combination of meeting the SPP mission trajectory requirements and the SPP launch system's capacity. Earth departure conditions at launch must satisfy the SPP mission trajectory requirements defined as launch target in three parameters: launch energy C3, right ascension of launch asymptote (RLA), and declination of launch asymptote (DLA). And the SPP launch system, a Delta IV Heavy launch vehicle with a Star 48BV upper stage, must deliver the SPP spacecraft to the launch target. The C3 of the launch target must be within the performance limit of the launch system. To ensure a high probability of launch against unexpected circumstances a backup launch window must be planned for the mission.

Launch opportunity for an interplanetary mission is usually scarce and depends on the specific mission trajectory and the planetary bodies to be encountered. The SPP mission has a very complex trajectory architecture called V<sup>7</sup>GA [1] that includes seven Venus gravity assisted flybys at both the inbound and outbound intersections of the Venus orbit. Launch opportunities for this V<sup>7</sup>GA trajectory occur every 19.2 months. The next launch opportunity after the primary launch window in July 2018 is March 2020. However the launch C3 for the March 2020 opportunity greatly exceeds the performance limit of the SPP launch system. It is therefore not a viable backup launch window for the mission.

A new launch opportunity is created by minor alteration of the SPP mission trajectory. An additional Venus flyby is added to the V<sup>7</sup>GA trajectory architecture changing the mission trajectory from V<sup>7</sup>GA to V<sup>8</sup>GA. The altered V<sup>8</sup>GA trajectory has a launch opportunity in May 2019, 9.6 months from the primary launch window, with launch C3 much lower than the C3 of the V<sup>7</sup>GA launch opportunity in March 2020 and being able to fit within the performance capacity of the SPP launch system. The May 2019 launch opportunity with the V<sup>8</sup>GA trajectory serves as the SPP backup launch window. Since the alteration retains the V<sup>7</sup>GA SPP trajectory architecture, the science objectives set for the SPP mission will be fully accomplished for the backup launch. The Launch C3 and DLA for the primary launch period are plotted in Fig. 1 and the ones for the backup launch period are shown in Fig. 2. More on the SPP launch windows and their associated mission trajectories will be included in the full paper.

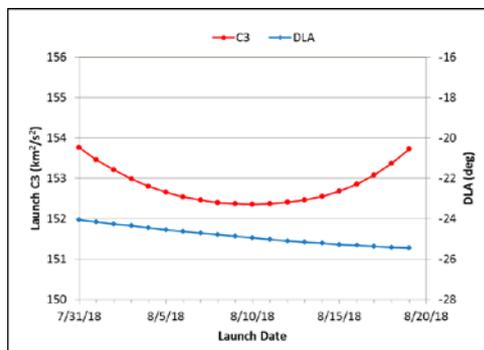


Fig. 1. Primary Launch Period.

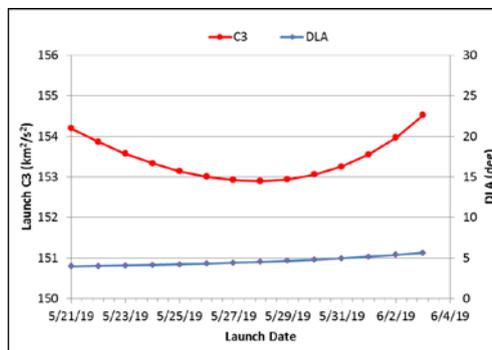


Fig. 2. Backup Launch Period.

### References

[1] Guo, Y., Trajectory Design of Solar Probe+ Using Multiple Venus Gravity Assists, AIAA Paper 2008-7365, 2008 AIAA/AAS Astrodynamics Specialist Conference, Honolulu, Hawaii, August 18-21, 2008.