EXTENDED MISSION TRAJECTORY OPTIONS FOR THE VAN ALLEN PROBES MISSION

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Abstract: *The Van Allen Probes mission, part of NASA's Living With a Star Program, successfully launched on August 30th, 2012 from the Cape Canaveral Atlas-V Space Launch Complex 41. The two year primary mission, which ended on November 1, 2014, consisted of two spin stabilized spacecraft in highly eccentric Earth orbits that provide insight into the dynamics of Earth's radiation belts by measuring the relevant in-situ environment (magnetic and electric fields) and key parameters of energetic particles and ions. The two spacecraft have slightly different orbital periods that cause one spacecraft to lap the other approximately four times per year. The difference in semi-major axes resulted in an offset in the natural precession rate induced by Earth oblateness, causing the lines of apsides (or petals) of the two orbits to deviate. The mission, which is currently in a bridge phase, is considering several extended mission trajectory options that alter the rate of petal separation and lapping rate. The limiting factor on the various options is fuel consumption.*

The metric used to evaluate the degree of petal separation is the difference in solar phase of apsides angles of the two spacecraft, which describes the orbit orientation with respect to the sun. The solar phase of apsides angle is defined as the angle between the line of apsides (pointing towards apogee) projected into the ecliptic plane and the Earth-Sun line. Based on the current orbital configuration (the difference in apogee altitude between the probes is 140 km), the delta in solar phase of apsides is increasing at 0.8 deg per year. One of the options being considered is increasing the altitude difference by 300%, which would cause the delta in solar phase of apsides to increase at 3.6 deg per year. The maneuvers that yield the chosen extended mission orbit configuration are currently planned for June 2015. This is the preferred date because the attitudes of the spacecraft are sun-pointed and the local solar time at apogee will be dusk. Apogee local solar times at dawn or dusk enable the most efficient maneuver executions as the inertially fixed thrust vector is aligned with the velocity vector at either apses. This paper will detail the design and impact of all the trajectory options being considered for extended mission.

An advantage to accelerating the petal separation by means of further deviating the relative semi-major axes would be a faster lapping rate. This is considered advantageous by the Van Allen Probes Science Team as it allows targeting a specific geomagnetic relative position during each close approach event, specifically, enabling the spacecraft to spend a period of time near the same Earth magnetic field line and take very unique measurements. Two such close approach events have already taken place to demonstrate the scientific value of these unique magnetic field measurements. The most recent of these close approach experiments was conducted in April 2015. A maneuver was executed on Van Allen Probe B on April 3, 2015 to place the two spacecraft along the same Earth

magnetic field line at the close approach on April 9, 2015. The 22 cm/sec maneuver resulted in the spacecraft being within a kilometer of the same magnetic field line. Figure 1 shows the difference in geomagnetic position from the same electric field line of the two spacecraft after execution of the trajectory correction maneuver. This paper will also detail the maneuver design, execution, and results of both events.

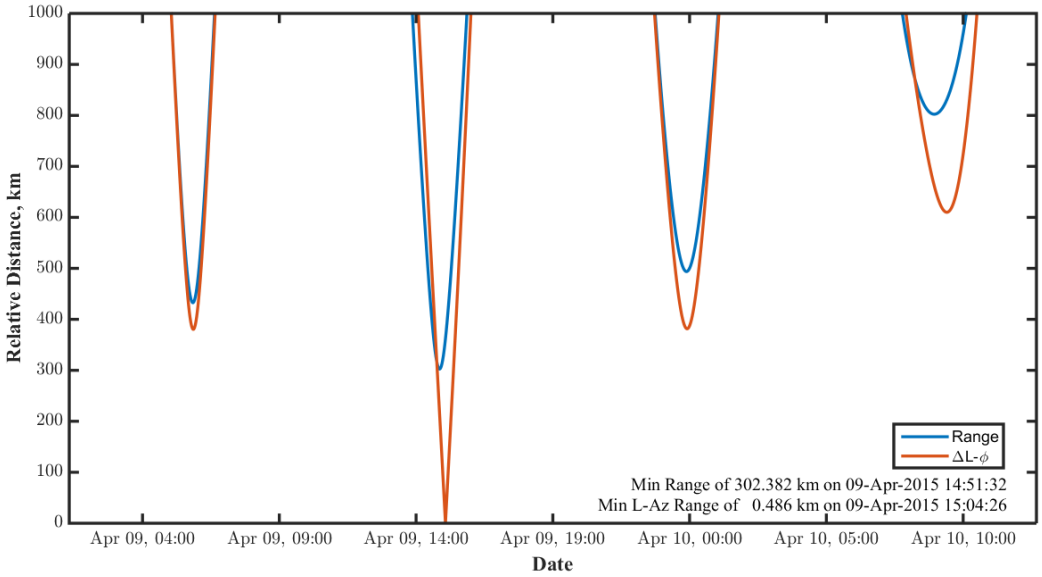

Figure 1. Difference in geomagnetic position between Van Allen Probe A and B.

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