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Mission Design, Operations and Optimization - Part 2 (2)

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TRAJECTORY OPTIONS FOR THE AKATSUKI RECOVERY

Abstract

On December 6th, 2010 the Japanese spacecraft Akatsuki arrived to Venus after a five-month journey. A 700 m/s Venus Orbit Insertion (VOI) was planned to put the spacecraft into a 4-day orbit, but due to a malfunctioning of a pressure-tank check valve, the maneuver was interrupted and Akatsuki is now drifting away from Venus. The mission team initially estimated that Akatsuki could come back to Venus in 6.2 years, and would need another large VOI to be captured into the 4-day orbit around Venus. The engineers however are concerned that the transfer time is too long for the instrumentation, and that the engine might not safely perform such a large, continuous burn.

This paper presents three recovery trajectories that are both shorter and safer than the original back-up plan, using the same amount of fuel. The trajectories use one large deep-space maneuver at perihelium and return to Venus with a lower relative velocity in less than 5 years, using a technique called V-Infinity Leveraging Transfer (VILT). VILTs are usually implemented to reduce the mission DV, but in this work one VILT was used to shorten the transfer time, and to improve the safety of the mission. In fact one large DV at perihelium can be accomplished with several short burns over a few–days period, as opposed to the orbit insertion maneuver, which must be completed within a few minutes. At the new Venus encounter, the reduced VOI will insert the spacecraft into the nominal 4-day orbit. To further reduce the risks, the presented solutions are designed so that even a partial VOI (150 m/s) would safely put the spacecraft into a gravitationally-captured trajectory around Venus, with another opportunity to complete the orbit insertion following just a few weeks later.

This combination of VILT and gravitational capture thus enables short, low-risk recovery options for Akatsuki. For these properties, the solutions presented in this paper are under investigation by the mission team and will probably be implemented in the next months. If so, Akatsuki will be the first mission to fly a gravitational capture at a planet, followed by BepiColombo, which will fly a gravitational capture at Mercury at the end of the decade.