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TRAJECTORY OPTIONS FOR THE AKATSUKI RECOVERY

Abstract

On December 7th, 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 inserted into the science orbit around Venus. The engineers, however, were concerned that the transfer time might not survive such a long transfer time (Nominal mission was about 5 years), and that the engine might not safely perform such a large, continuous burn.

This paper presents several 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 perihelion 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 contest one VILT is used to shorten the transfer time, and to reduce the mission risks. In fact, a DV at perihelion can be accomplished with several short burns over a few–days period, as opposed to orbit insertion maneuvers, which must be completed within a few minutes from the start.

The Akatsuki team eventually selected one of presented options as a nominal recovery trajectory. Prior to the scheduled perihelion maneuver, however, test maneuvers of the main engine showed that the thrust produces is far lower than expected. The team then resolved to dispose of the oxidizer (with a small DV gain) and use the propellant with RCS engines in place of the main engine. The perihelion burn was executed successfully, and now Akatsuki is on its way back to Venus. A capture at Venus is still possible, despite the large gravity losses of the RCS burn, thanks to the reduced VOI required by the VILT.

Upon arrival, different options are being considered to maximize the duration of the science phase at Venus. Some options have been recently presented at international conferences. In this paper we also briefly discuss another option with a gravitational capture to further reduce the risks of the new orbit insertion.