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Author: Mr. Michael Shoemaker
Kyushu University, Japan, shoemaker@aero.kyushu-u.ac.jp

Dr. Jozef van der Ha
Mission Design & Operations, United States, jvdha@aol.com

TRAJECTORY ESTIMATION OF THE HAYABUSA SAMPLE RETURN CAPSULE USING OPTICAL SENSORS

Abstract

The sample return capsule (SRC) for the Japanese Hayabusa asteroid mission will return to Earth in June 2010. Because the SRC will re-enter the atmosphere during nighttime, it will appear as a bright light source during the high-heating portion of the trajectory. The present study describes the development of an operational capability to optically observe this part of the re-entry capsule's descent through the atmosphere. The two primary purposes for this system are: (1) to provide real-time trajectory estimates to the JAXA ground teams for capsule recovery, (2) to allow for post-flight verification of capsule performance and design methodology. Such information will be useful in the design of future interplanetary re-entry missions.

The development builds on the lessons learned from the observation campaigns for the Genesis and Stardust interplanetary re-entry vehicles in 2004 and 2006, respectively. Even though these past observation campaigns provided a trajectory reconstruction capability, the primary requirement was to evaluate the thermal protection system performance via optical measurements. The present study focuses on the system design for trajectory estimation via an Extended Kalman Filter (EKF), using ground-based and/or aerial measurements of the SRC angular position.

The SRC angular position is measured relative to known star positions from recorded images and video. The EKF estimates the SRC position, velocity, and aerodynamic lift and drag. The estimated state parameters and their covariances are propagated down to the surface to refine the predicted landing ellipse. The EKF is tested with angular measurements collected during the Stardust SRC re-entry mission, and produces estimates with accuracy similar to those of the geometric methods used by the NASA observation teams. These results, combined with computer simulations of the EKF for the Hayabusa re-entry, give confidence in the ability to estimate the actual Hayabusa trajectory. Lastly, future plans for actual implementation and operations in June 2010 are discussed.