62nd International Astronautical Congress 2011

Paper ID: 9959
oral

ASTRODYNAMICS SYMPOSIUM (C1)
Guidance, Navigation and Control - Part 1 (7)

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REDUCING THE UNCERTAINTY OF HAYABUSA'S LANDING POSITION ON ITOKAWA

Abstract

The landing of Hayabusa on the asteroid Itokawa in 2005, and subsequent sample return of surface particles in 2010, has ushered in a new era of small-body exploration: one where in-situ and sample return measurements are fact. But to increase the scientific return from the mission, the collection point of the particles should be correlated against knowledge of the asteroid composition. Unfortunately, when Hayabusa landed, the position uncertainy was large due to few sensors taking data. In this paper, we attempt to reduce the landing position uncertainty by applying known thruster actions and an improved gravity model to a simulation of the landing, and correlating these results with actual altitude measurements.

During the descent of Hayabusa, several sensors were turned off and only altitude data was recorded. Other attitude and position states were not transmitted back to Earth. The state of the thrusters, however, was recorded. Together with a model of the thrusters, a simulation of Hayabusa's descent can now be accurately reconstructed.

In addition, post processing of mission data has allowed an advanced polyhedral gravity model to be created. As has been shown in the literature [Scheeres, 1997], polyhedral models can accurately represent the gravity field of irregular objects down to the surface, whereas harmonic or ellipsoidal models may often have singularities. This model allows us to correspond changes in altitude against the increase of gravity during the descent, increasing vertical position estimation accuracy.

The improved Hayabusa model, created with high fidelity and able to account for thruster firings, fuel changes and sample probe dynamics, allows us to significantly reduce the landing position uncertainty. Furthermore, the simulation also allows us to compare photographs taken during decent against those created by a computer graphics-based simulator, which serves as verification of results. We present the model created and compare it against previous results. We then use this model to estimate the position of Hayabusa's landing, and attempt to pinpoint it on high altitude photographs. Finally, we compare photographs taken during the descent of Hayabusa against those created in the simulation to verify the accuracy of the method. The results serve to assist scientists in determining the composition of the asteroid Itokawa from only a few sample particles.