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MARCOPOLO-R PROXIMITY TRAJECTORY ANALYSIS AND DESIGN FOR BINARY ASTEROID 1996 FG3.

Abstract

In the frame of the studies performed for the asteroid sample retrieval mission MarcoPolo-R, special relevance is being given to the analysis and design of the mission phase in which the S/C will fly in close formation with the target body. The motion around an asteroid shows distinct peculiarities due to the low mass of the asteroid, which implies that other perturbations may be large with respect to the body central gravity, to the irregular shape of the asteroid, which in some cases can be very far from being a sphere causing the classical spherical harmonics modelling to lose accuracy, and to the fact that many asteroids are in fact binary systems, as for the old MarcoPolo-R baseline target 1996FG3. The analysis and design of the close formation flying with an asteroid is complicated further by the limited knowledge available of the physical characteristics of the asteroid environment (mass, size, shape, rotation of the primary, secondary mass size and orbit...). The main tasks carried out by Deimos for the proximity phase analysis were aimed at assessing the delta-V cost and feasibility (stability, safety, and operations) of different types of orbit about the asteroid to execute asteroid global characterisation, radio science experiment and local characterisation prior to descent and landing. The orbit types considered were 9:21 polar orbits, with altitude, inclination and RAAN, controlled such to maintain safe distance to the asteroid and constant orientation of the orbital plane with respect to Sun direction, and with different control schedules, terminator plane photo-stable orbits, stabilised by the SRP effect, inertial hovering and body fixed hovering; for the body fixed hovering two guidance modes have been defined, based on the use of full asteroid-relative position observables or only on altitude + relative surface velocity data. This latter mode was further optimised to reduce the resulting longitude drift over the hovering duration. In order to take into account both the effect of different orbit reference conditions (for instance, reference asteroid distance or orbital radii) and of the variability of the environment parameters, two main sets of simulations were carried out: a first set in which nominal environment conditions were used and the orbit reference altitudes were varied, and a second set in which extensive MonteCarlo runs were used to simulate nominal orbit scenarios in different stochastic realisations of the environment, in which physical coherency of each shot was always guaranteed.