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Author: Mr. Francisco da Silva Pais Cabral
G.M.V. Space and Defence, S.A., Portugal

Mr. Ángel Palomino
GMV Aerospace & Defence SAU, Spain, Spain
Mr. Pablo Colmenarejo
GMV Aerospace & Defence SAU, Spain
Mr. Andrea Pellacani
G.M.V. Space and Defence, S.A., Spain
Mr. Victor Manuel Moreno Villa
G.M.V. Space and Defence, S.A., Spain
Mr. Fabien Dahmani
G.M.V. Space and Defence, S.A., Portugal
Ms. Mariella Graziano
GMV Aerospace & Defence SAU, Spain

TRAJECTORY AND GNC STRATEGY DESIGN FOR A FAST DEVELOPMENT MISSION TO APOPHIS – A LESSON IN THE RE-USE OF HERA

Abstract

On 13 April 2029, Apophis will pass less than 35 000 km from Earth resulting visible from Earth to the naked eye. Being closer than satellites orbiting in the Geostationary ring, Apophis is a perfect target for a potential future Planetary defence small sat mission.

In this paper, GMV presents its GNC and trajectory design solution for such a mission, based on its experience with the HERA GNC developments. The trajectory options and GNC strategies for an Apophis orbiter are addressed with focus on the realistic consideration of constraints that arise for a smallsat platform and a low cost mission, namely: 1) consideration of tight system constraints (thermal, communications, and reduced sensor suite) in the trajectory and GNC strategy designs; 2) Re-use of existing technologies to reduce mission developments costs and to ensure schedule compliance for a mission arrival before Apophis fly-by to Earth on April 2029; 3) minimization of the operational costs and ground effort by increased AOCS/GNC autonomy, while the asteroid environment proves to be additionally challenging due to the weak dynamical environment where small maneuverers can only be made with limited actuation accuracy, compared to typical velocities. Furthermore, only a restricted propellant budget is available to accommodate all the identified constraints.

GMV's experience in the design of the proximity operations and GNC sub-systems for small bodies, including the HERA mission, proved crucial in generating and analysing feasible trajectory options. Different strategies were compared, such as hyperbolic arcs (HERA strategy), Lagrange Point Orbits, Pseudo-hovering and Self-stabilised Terminator Orbits (SSTO's).

For each option the required autonomy level by the GNC sub-system for optimisation of the spacecraft's safety and scientific return was assessed. Following the maximisation of a cost-efficiency approach, the suitability to the on-board image processing techniques used in HERA - feature tracking and centroiding - to an Apophis mission is studied.

As the main outcome of this work, GMV advocates for a low-cost fast development of a mission to Apophis based on the HERA GNC developments. Furthermore, a first proposal for the mission's proximity

operations and GNC strategy definitions is presented along with a discussion on the main challenges and limitations.