Paper ID: 47997
oral
student

IAF ASTRODYNAMICS SYMPOSIUM (C1)
Attitude Dynamics (1) (3)

Author: Mr. Andrea Colagrossi
Politecnico di Milano, Italy

Prof. Michèle Lavagna
Politecnico di Milano, Italy

CISLUNAR NON-KEPLERIAN ORBITS RENDEZVOUS & DOCKING: 6DOF GUIDANCE AND CONTROL

Abstract

Future science and exploration missions are supposed to exploit cislunar environment as effective outpost to advance technology readiness in view of human presence beyond Earth. These ambitious space programmes entail modular large space infrastructures to be available in non-Keplerian orbits, in the Moon vicinity, to run manned and robotic activities. The latter in preparation of a safe and reliable operational environment for humans to come. As ISS operations teach, in space outposts ask for complex logistic, which leans on rendezvous and docking/undocking capabilities between space segments and embrace different engineering disciplines.

So far, no mission performed autonomous and accurate proximity operations but in LEO. Conversely, several flown missions were operational on non-Keplerian orbits, exploiting the increased knowledge about n-body dynamics modelling for trajectory design. However, existing studies deeply investigating the 6DOF relative dynamics in non-Keplerian orbits are somewhat missing; this area of investigation is now mandatory to support the cislunar infrastructure design and implementation, assessing and addressing practical solutions for GNC strategies, which shall be applicable to reliably manage proximity operations of the lunar gateway.

In this direction, the paper discusses and justifies the 6 DOF model, based on full Ephemeris, implemented to analyse the relative dynamics and address the relative GNC design for non Keplerian orbits proximity operations. It is remarked that a high-fidelity dynamics modelling is fundamental to support the high-level design of 6DOF GNC strategies.

The paper particularly stresses the beneficial effects of a coupled 6DOF analysis, to better leverage the natural dynamics to design effective and efficient approaching trajectories: the greater flexibility offered by the increased model complexity gets to a design that addresses GNC functional and performance requirements. On board resource limitations and mission reliability is highlighted in the discussion.

As an example, dual-spin attitude stabilization is discussed as a beneficial output of the coupled dynamics model, while trading off the proximity trajectory design and guidance strategy alternatives. Moreover, different case studies are presented to underline the fruitful effects of the coupled 6DOF and the relative dynamics approach here adopted for non-Keplerian orbit GNC design.