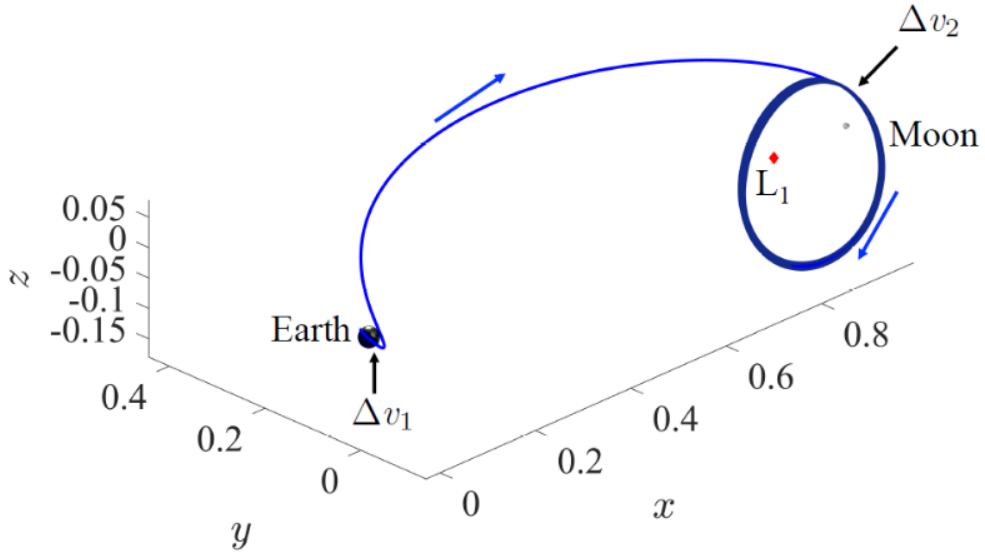
Technische Universität Braunschweig

Study Thesis/ Master's Thesis
(German/English)

Propagating orbits beyond Earth into lunar regions

Current trends in spaceflight, such as the realization of megaconstellations (e.g., Starlink and OneWeb) or increasing launch rates in general, lead to growing object numbers. While the vast majority of these objects is located in orbits bound to Earth, object numbers are also increasing in the region of space around and in the vicinity of the Moon (cis-lunar). Today, most efforts regarding the observation and cataloging of objects focus on orbits close to the Earth. However, with growing object numbers in the cis-lunar region dedicated observation capabilities and environment evolution models become increasingly relevant. As for the Earth, accurate models and object catalogs are the base for mission planning, collision risk estimation, and situational awareness in general.



Sketch of depicted transfer trajectory and L1-halo-orbit (Folta, David, et al. Astrodynamics convention and modeling reference for lunar, cislunar, and libration point orbits. No. NASA/TP-20220014814. 2022.)

In contrast to the near-Earth environment, the forecasting of satellite trajectories, denoted as propagation, is much more complex due to the chaotic dynamics. A physically sound propagator has to account for the gravitational forces of Earth, Moon and Sun, the complex gravitational field of Earth and Moon and solar radiation pressure. Difficulties arise from the fact that Earth, Moon and Sun are not static, but change their position relative to each other. In a similar way the gravitational fields of Earth and Moon rotate in inertial space. The resulting force model has to be integrated numerically. At the Institute of Space Systems, we want to develop such a propagator to expand our research regarding the modelling of resident space object populations, space situational awareness and on-orbit collision risk to the cis-lunar environment. Such a propagator can similarly be applied to other interplanetary trajectories.

In this context, we are offering multiple thesis topics covering the following aspects:

- Research and familiarization with the basics of orbit propagation in the cis-lunar environment, and the state representations (coordinate systems) involved.
- Design, implementation and testing of a numerical propagator for a n-body point mass problem accounting for precise planetary ephemerides (i.e. Earth, Moon and Sun)
- Design, implementation and testing of a numerical propagator accounting for the complex gravitational field of the Moon
- Design, implementation and testing of a solar radiation pressure model accounting for shadowing conditions due to Earth and Moon

For these and similar tasks we are looking for motivated students who are keen on modelling, programming and simulation of complex problems.

Contact: Antonio Depardon

Tel. 0531 / 391-9980, E-Mail: antonio.depardon@tu-braunschweig.de

Hermann-Blenk-Str. 23, 38108 Braunschweig