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Contribution of PRIDE VLBI to the ephemerides of Jupiter's moons

Content

In the 2030s, the ESA JUICE and NASA Europa Clipper missions will explore the Jupiter system and provide unprecedented insights into the dynamics of the Galilean satellites. A refined ephemerides estimation will enhance our understanding of their origin and thermal-orbital evolution. However, achieving a robust and consistent solution that matches the low uncertainty levels predicted by current simulations will be challenging. This is due to the need for models to reproduce the spacecraft and moons' dynamics accurately enough for the statistical uncertainty estimates to be physically meaningful.

To overcome these challenges, we propose a gradual approach, starting with local estimations of the flyby moon's state, which are then carefully analysed and validated before a global solution can be reconstructed. We investigate the role of JUICE's Planetary Radio Interferometry and Doppler Experiment (PRIDE) in this process. PRIDE will provide independent VLBI measurements of the spacecraft's angular position, complementing the line-of-sight constraints from classical radio science. We simulated VLBI measurements for JUICE in various data acquisition and quality scenarios and identified eleven opportunities for simultaneous VLBI observations of the JUICE and Europa Clipper spacecraft. Our covariance analyses highlight how PRIDE VLBI observations can significantly improve the satellites' local state solutions, most notably in the out-of-plane direction.

The PRIDE data represent a powerful addition to the classical radio science solution and play a key role in progressing from local estimates towards a consistent, unprecedentedly accurate global solution for the moons' dynamics. This research paves the way for a deeper understanding of the Galilean satellites and their complex interplay with Jupiter.

Primary author(s) : Ms. FAYOLLE-CHAMBE, Sam (Delft University of Technology)

Co-author(s) : Dr. CIMO, Giuseppe (Joint Institute for VLBI ERIC); Prof. GURVITS, Leonid (JIVE); Dr. DIRKX, Dominic (Delft University of Technology); Dr. LAINEY, Valery (Observatoire de Paris); Prof. VISSER, Pieter (Delft University of Technology)

Presenter(s) : Dr. CIMO, Giuseppe (Joint Institute for VLBI ERIC)

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