Applications of Planetary Radio Interferometry and Doppler Experiment (PRIDE) for Radio Occultation Experiments

**Planetary Radio Interferometry and Doppler Experiment (PRIDE)**

PRIDE is a generic experimental setup of on-board and Earth-based radio devices and facilities, with the goal of providing precise estimates of spacecraft states vectors. This is done by performing precise Doppler tracking of the spacecraft carrier signal and VLBI-style correlation of these signals in phase referencing mode.

**Generic PRIDE configuration**

- Celestial body - target
- Spacecraft
- Background sources
- VLBI network and 2-way tracking stations

**Block-diagram of data processing and analysis**

Reference source coordinates

Raw observational data

A priori state vector of the spacecraft

- Broad-band correlation of the reference source with the far-field delay model
- Broad-band correlation of the S/C data band with the near-field delay model
- Residual group delay and phase
- Residual group delay and phase
- Residual phases of the carrier and tones

Delay/phase corrections

Reconstruction of the apparent state vectors of the S/C

**PRIDE as a radio science instrument**

By allowing an accurate examination of the changes in phase and amplitude of the radio signal propagating from the spacecraft to one or more stations on Earth, the PRIDE technique can be used for several fields of research:

- Atmospheric and ionospheric structure of planets and satellites, planetary rings.
- Planetary gravity fields.
- Planets’ shapes, masses and ephemerides.
- Solar plasma.
- Aspects of the theory of general relativity.

**Radio Occultation Experiments with PRIDE**

The radio frequency transmission from a spacecraft occulted by a planetary body and received on Earth can be used to study the body’s atmosphere and ionosphere.

**PRIDE radio occultation experiment with ESA’s VEX**

![Diagram of data processing and analysis](image)

The perturbation caused by the presence of the extended atmosphere is measured from Earth and it is converted into a refractivity profile. From the refractivity profile, information is derived about the electron distribution in the ionosphere and temperature-pressure profile in the neutral atmosphere.

The PRIDE technique can play a key role in the determination of the refractivity profile, by allowing an accurate extraction of the Doppler effect due to the geometrical flight path.

**Optimization of the PRIDE experiment setup for radio occultation data analysis**

To improve the setup of the experiment, it is necessary to identify the different sources of uncertainties of PRIDE that would have an effect on the determination of Δf and the impact parameter.

This analysis will lead to the prediction of uncertainties of atmospheric properties (e.g. n_e and n_m) given a particular observational setup and target spacecraft, which can be of great use when performing preliminary design studies of future radio occultation experiments.

**Future planetary radio occultation experiments with PRIDE**

By tracking ESA's VEX with several stations of the EVN during its next radio occultation campaign in October 2013, the error propagation analysis of the PRIDE setup will be validated.

Using the software tools developed, a case study with the upcoming ESA’s JUICE mission will be performed, to estimate the uncertainties in the ionospheric electron and neutral number densities for hypothetical radio occultation experiments at Jupiter with the PRIDE technique (this analysis can also be extended to study the ionospheres of Io, Europa, Ganymede and Callisto).