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VAPRE: Facilitating Planetary Probe Mission Design and Entry Site Selection

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In the pursuit of deciphering the formation of our solar system, the exploration of the compositional and dynamical structure of planetary atmospheres with entry probes plays a crucial role. A probe's measurements provide insight into an atmosphere's deeper composition and dynamical processes not accessible via remote sensing, providing key information on the origin and possible migration of planets during early formation phase. A planetary entry probe mission has been in discussion in several Planetary Science Decadal Surveys, one to Saturn has been identified as a mission of highest priority in the current one 2013-2022, and a mission to Uranus and/or Neptune carrying a probe is being considered as a Flagship mission in the next one spanning 2023-2032.

In the development of such missions, the probe approach and delivery trajectory is a critical element to mission success, including ring avoidance, and targeting of highly desirable regions in the atmosphere, while balancing other requirements such as providing an optimal communication geometry between the probe and the relay spacecraft while meeting the mission's science objectives. Due to the complexity of the problem, mission concept studies are usually limited to the investigation of a limited number of specific trajectories and probe delivery opportunities to a very small, pre-defined range of latitudes while leaving a huge trade space unexplored.

The tool VAPRE (**V**isualization of **A**tmospheric **PR**obe **E**ntry conditions) has been developed to enable a fast and wide-range evaluation of entry conditions for planetary probes, spanning the complete range of latitudes for each of the three planets. VAPRE allows a rapid assessment of feasible entry sites by evaluating a large number of arrival trajectories based on their hyperbolic arrival velocities with respect to parameters such as the flight path angle and the relative entry velocity of the probe at the entry interface point. VAPRE facilitates the mission design process by combining the evaluation of technical feasibility and science value for the investigated scenarios to assess potential entry sites. VAPRE is developed in the framework of IPED (**I**mpact of the **P**robe **E** ntry zone on the trajectory and probe **D**esign), which is a two- to three-year research study to investigate both the impact of interplanetary and approach trajectories on the feasible range of

entry sites as well as on probe design, considering Saturn, Uranus, and Neptune as target bodies.

In this paper we fully demonstrate the functionalities of the VAPRE tool on a case scenario for a mission to the Ice Giants.

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