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Determination of Soil Physical Properties with the HP^3-Experiment Suite

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Abstract

Soil physical properties are key values for the understanding of planetary surfaces, which have relevance for atmospheric exchange processes, wind transport processes and account in the exploration of the planetary development.

The HP^3 – Heat Flow and Physical Properties Package – will detect soil physical properties and will allow the measurement of the temperature dispersion and the heatflow to determine the planetary heat flux. The HP^3 package is designed for small geophysical lander units, like the Humbold payload package on the ExoMars mission. The HP³ instrument consists of a mole carrying a package of thermal and electrical sensors to a depth of five meters. Beside the payload elements Thermal Excitation and Measurement Suite (TEM) and a Permittivity Probe (PP) the HP^3 experiment contains the sensors for the forward motion and the tilt information of the payload compartment (ACTIL).

ACTIL – ACceleration and TILtmeter – and the tether length measurement build up the depth control of the HP^3 experiment. The static accelerometer of ACTIL measures the inclination of the payload compartment wrt the gravity vector.
The data derived from these ACTIL sensors and the tether length sensor yield to the calculation of the forward motion vs. time and the penetration depth of the mole in the planetary surface. The 2-axis tilt and the tether length measurements were demonstrated successfully already on the HP^3 engineering model during various functional tests at ambient and under thermal vacuum.

A pile driving model links the mole soil penetration with soil physical properties. It's a correlation between hammering energy, mole geometry, soil resistance and advancement per stroke, derived from ACTIL and the tether length sensor. With a pile driving model soil physical properties like bulk porosity, bulk density and soil strength can be calculated. In former studies this model was applied to predict the penetration profile of the mole.

The present design of ACTIL as part of the HP^3 instrument, its measurement strategy and the depth determination will be presented. In this context the experimental results of the mentioned former studies will be shown. The actual status of the pile driving model will be presented as well as derived results. Its application for the HP^3 experiment will be explained.

The presentation will comprehend the engineering aspects of the depth determination of the HP^3 experiment and its scientific benefit with the determination of soil physical properties out of the forward motion.