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Instrumented Moles for Planetary Subsurface Regolith Studies

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Soil-like materials, or regolith, on solar system objects provide a record of physical and/or chemical weathering processes on the object in question and as such possess significant scientific relevance for study by landed planetary missions. In the case of Mars, a complex interplay has been at work between impact gardening, aeolian as well as possibly fluvial processes. This resulted in regolith that is texturally as well as compositionally layered as hinted at by results from the Mars Exploration Rover (MER) missions which are capable of accessing shallow subsurface soils by wheel trenching.

Significant subsurface soil access on Mars, i.e. to depths of a meter or more, remains to be accomplished on future missions. This has been one of the objectives of the unsuccessful Beagle 2 landed element of the ESA Mars Express mission having been equipped with the Planetary Underground Tool (PLUTO) subsurface soil sampling Mole system capable of self-penetration into regolith due to an internal electromechanical hammering mechanism. This lightweight device of less than 900 g mass was designed to repeatedly obtain and deliver to the lander regolith samples from depths down to 2 m which would have been analysed for organic matter and, specifically, organic carbon from potential extinct microbial activity.

With funding from the ESA technology programme, an evolved Mole system – the Instrumented Mole System (IMS) - has now been developed to a readiness level of TRL 6. The IMS is to serve as a carrier for in situ instruments for measurements in planetary subsurface soils. This could complement or even eliminate the need to

recover samples to the surface. The Engineering Model hardware having been developed within this effort is designed for accommodating a geophysical instrument package (Heat Flow and Physical Properties Package, HP3) that would be capable of measuring regolith physical properties and planetary heat flow. The chosen design encompasses a two-body Mole consisting of a 'tractor' element containing the hammering mechanism jointed to a trailed compartment housing the instruments as well as some front-end electronics, tethered to surface controls and instruments.

This presentation will highlight the design of the IMS and of HP3 and will describe results of comprehensive functional and environmental tests that included soil penetration to depths beyond 2 m, thermal vacuum functional tests, as well as vibration testing of the stowed system. HP3 as an integrated, Mole-based instrument has been proposed as an experiment for the Geophysics Package (GEP) of the ESA ExoMars mission.