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GEMS – a mole to explore the interior of Mars

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Mission proposal involving DLR on the NASA short list

The final contenders in NASA's Discovery programme, which invites scientists to propose unmanned planetary missions, have been announced. The Geophysical Monitoring Station (GEMS) for Mars mission proposal has made it to the final round of decision-making. The German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) is significantly involved with the geophysical experiment, which will explore the interior of Mars. The main objective of the mission, which could launch in early 2016, is to obtain a unique impression of the 'interior life' of Mars through a series of direct measurements.

An instrumented mole system equipped with temperature sensors, the Heat Flow and Physical Properties Package or 'HP Cube' (HP3), will penetrate up to five metres into the surface of Mars to measure the heat flow from the Martian interior. "HP3 will give us new insights into the thermal development of Mars, and to water reserves that could be concealed beneath its surface. This experiment has been carefully planned, and its outcomes could drive Mars research significantly forward," states Tilman Spohn, scientific lead for HP3 and Head of the DLR Institute of Planetary Research in Berlin-Adlershof. "DLR is proud at the fact that its HP3 experiment is one of the successful mission proposals and could be a part of the next NASA Discovery mission. The involvement in the GEMS mission proposal falls within DLR's strategy of building on international collaboration in the exploration of space." Following the Mars Pathfinder mission back in 1997, DLR is currently a partner on two current missions in the NASA Discovery programme. DLR is contributing cameras, spectrometers and image processing expertise on the MESSENGER spacecraft to Mercury and on the Dawn spacecraft, which will be exploring the asteroids Vesta and Ceres. The aim of the Discovery missions is to explore the Solar System with a limited budget of 500 million US dollars.

Three million US dollars to develop the project further

The GEMS science team, led by Bruce Banerdt at NASA's Jet Propulsion Laboratory in Pasadena, California, will receive three million US dollars to develop this project further. "The experiment has already reached a high level of technological maturity – which is why our HP3 proposal is ahead in development terms compared to similar experiments," explains Tilman Spohn. In the course of the last year, 28 mission proposals have been submitted to NASA. Besides GEMS only two other mission proposals are left in the race for this Discovery mission. The Titan Mare Explorer (TiME) is intended to explore a hydrocarbon lake on Saturn's moon Titan. The Comet Hopper is designed to conduct detailed investigations of comet 46P/Wirtanen. The final decision will be taken in 2012, with a launch most likely be in 2016.

A fully automated journey to the interior of Mars

The HP3 experiment uses an electromechanical impact mechanism capable of driving an instrument container into the Martian surface to a depth of up to five metres. "Until now, a fully-automatic mole of this kind has never been used on any planetary body in our Solar System," states Tim van Zoest, a physicist at the DLR Institute of Space Systems in Bremen, where the impact mechanism was developed. "Comparable experiments to analyse material below the planet's surface have only been conducted manually on the Moon during the US Apollo missions 15 and 17 in the early seventies. But the tools used then were similar to conventional drills, drilled into the Moon's surface by muscular power, much like a corkscrew."

The sensors on HP3 were developed at the DLR Institute of Planetary Research in collaboration with the Space Research Institute of the Austrian Academy of Science in Graz. In particular, the mole will monitor the heat flow inside the Martian surface. “The precise and direct measurement of heat flow under the surface will enable us to determine the heat produced deep inside Mars. This will give us insights into the composition of the Red Planet and its ongoing cooling process, which is related to the present volcanic activity,” explains Matthias Grott from the DLR Institute of Planetary Research. “In addition, HP3 will study the geological stratification of the first five metres below the surface of Mars – especially the presence of ice – through measurement of the geoelectrical properties of the ground,” adds the physicist.

Further European involvement in the GEMS mission proposal involves the seismometer, under French management control at the Institut de Physique du Globe de Paris (IPGP). The Max-Planck Institute for Solar System Research in Katlenburg-Lindau, in the German Harz region, is developing a system that will be able to install on the seismometer on Mars, under the leadership of Ulrich Christensen. The seismometer will record Marsquakes and asteroid impacts. These seismic vibrations - similar to those on Earth – pass through the entire body of the planet. Seismometer measurements can therefore be used to infer the size and properties of the crust, mantle and planetary core of Mars. The third scientific payload in the GEMS mission proposal is an experiment developed under the management of the US company Lockheed Martin, and is intended to increase our understanding of the internal structure of Mars.

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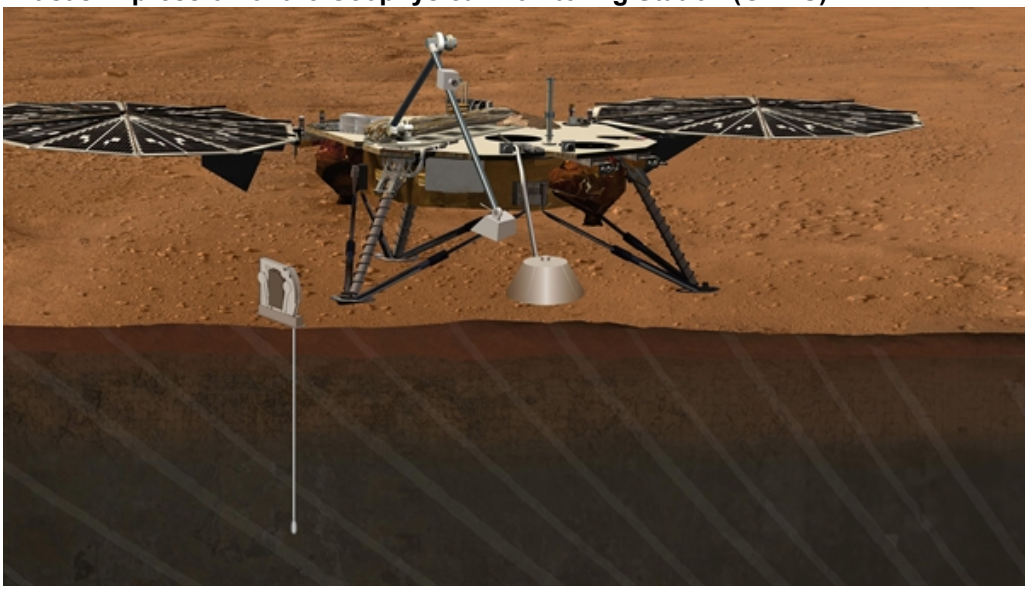
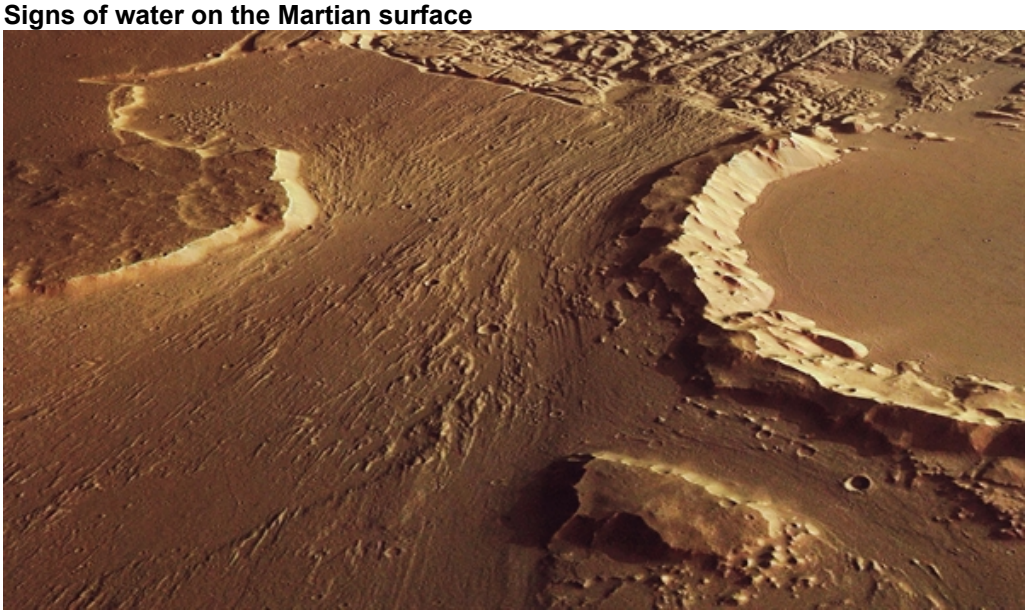
Artist's impression of the Geophysical Monitoring Station (GEMS)



The 'mole' experiment 'HP3' (Heat Flow and Physical Properties Package) is intended to determine the heat flow in the Martian interior and to determine the planet's physical composition. For this purpose, a special electromechanical impact mechanism drives an instrument container down to a depth of up to five metres below the surface of Mars (left). In these first five metres below the surface, the geoelectrical properties of the ground are to be measured as part of the search for subsurface ice deposits.

Credit: NASA/JPL.

Signs of water on the Martian surface



During the early formation of Mars, vast volumes of water flowed across its surface in various regions. The Kasei Valley in the central Martian highlands, now dry, supports this fact. At the same time, and possibly in the more recent geological past, numerous volcanoes were active on Mars. Evidence of this is visible on the right hand side of this image, which shows an impact crater measuring about 30 kilometres in diameter, and now filled with solidified lava. If selected by NASA for the new Discovery mission, the Geophysical Monitoring Station (GEMS), would land on Mars in 2017 with the goal of investigating the interior of the Mars by conducting a series of geophysical experiments. This should answer questions about whether or not any water is still present. It could be there in the form of ice, stored in cavities below the surface. A better understanding of the development of volcanic activity throughout the history of Mars could also be achieved.

This perspective view of the Kasei Valley is based on stereo images from the High Resolution Stereo Camera (HRSC) system, operated by DLR on the European Mars Express spacecraft which has been orbiting Mars since the end of 2003.

Credit: ESA/DLR/FU Berlin (G. Neukum).

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