

MEMO: Mars Environment and Magnetic Orbiter: a Cosmic Vision proposal

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Recent observations by the ESA spacecraft Mars Express, the two NASA Rovers Opportunity and Spirit, as well as by the NASA probe Mars Global Surveyor, have changed our view on the evolution of Mars. The most dramatic results are the limited amount of visible minerals related to the action of water at its surface, the very intense lithospheric magnetic fields, and the current weak ion escape driven by the solar wind. These observations suggest that the period of a “wet Mars” was short and that Mars lost its water before 3.5 Gyr ago, when the magnetic field of Mars died out. Among the different questions that are raised by existing results, the role of the superficial magnetic field shielding Mars’ surface and lower atmosphere from the high-energy ions and the dependency of the escape rate on solar conditions are first order questions that

cannot be addressed without new measurements by a dedicated mission. However, these questions cannot be fully solved without understanding how carbon dioxide, water and chemical species are cycled through atmosphere, clouds, polar caps and other reservoirs.

An integrated view of Martian matter and energy cycles, from the surface up to solar wind interaction regions and beyond, is the next step toward deciphering past climate. The Mars Environment and Magnetic Orbiter mission (MEMO) is devoted: (1) to measure temperature, wind and chemical composition in order to characterize processes coupling low, middle and high atmospheric layers, (2) to describe atmospheric oxidation processes and to search for organic chemical compounds, (3) to measure water isotopic fractionation in the low atmosphere in order to characterize water sources, sinks and transport, with a focus on polar processes, (4) to investigate the dependency of atmospheric and neutral and ion escape dynamics on short and long timescales versus solar wind and radiation variabilities, (5) to map the crustal magnetic field with an unprecedented spatial resolution that would allow a more precise timing of the dynamo and its disappearance, (6) to describe the current systems formed by the interactions between the solar wind and the lithospheric field.

MEMO is composed of a low periapsis (130 km) and apoapsis (1000 km) main platform and of a high apoapsis micro-satellite, on a 77° inclination. The micro-satellite will perform *in situ* and simultaneous measurements of the solar wind conditions and will permanently monitor the solar EUV flux. One full Martian year of operation is foreseen to cover seasonal/local time/latitude/altitude variabilities. The proposed low-periapsis orbiter will consist of the following elements:

- An "exospheric – upper atmosphere Package" to characterize the thermosphere, ionosphere, exosphere and solar wind interaction regions, including low and high energetic ion spectrometers, thermal and energetic neutral spectrometers, a UV airglow spectrograph and a X-ray mapping spectrometer.
- A "Magnetic Field Package", to characterize the magnetic signature of the lithosphere, and in particular the contrasts between magnetized and demagnetized areas, which cannot be accomplished with the present MGS coverage. Instruments will include a magnetometer and a plasma package consisting of an electron spectrometer completed by plasma wave detectors (Mutual Impedance and Langmuir Probes and a Magnetic Search Coil).
- A "low-middle atmosphere Package", including a wide-field micro-camera, an IR dust analyzer and a sub-millimeter spectrometer, to measure water vapour

and its isotope (HDO), a few key atmospheric gases and the temperature/wind field up to high mesospheric levels.

A mission like MEMO would ideally complete the present European programme for the exploration of Mars by contributing to our understanding of what has made the Earth suitable for life and not Mars. MEMO will use controlled aerobraking which is also of interest for the Exploration programme. Operation of a two-spacecrafts constellation at Mars also provides the necessary experience for the Exploration program.