A NETWORK OF GEOPHYSICAL OBSERVATORIES FOR MARS. W. Bruce Banerdt[1], Ulrich Christensen[2], David Crisp[1], Veronique Dehant[3], Greg Delory[4], Philippe Lognonné[5], Christophe Sotin[6], and Tilman Spohn[7], [1]Jet Propulsion Laboratory, California Institute of Technology (M.S. 183-501, 4800 Oak Grove Drive, Pasadena, CA 91109; bruce.banerdt@jpl.nasa.gov), [2]Max Plank Institute for Solar System Research, Katlenburg-Lindau, Germany, [3]Royal Observatory of Belgium, Brussels, Belgium, [4]University of California, Berkeley, California, [5]Institut de Physique du Globe de Paris, France, [6]University of Nantes, France, [7]DLR Institute of Planetary Research, Berlin, Germany.

Introduction: For the past 30 years there has been a strong consensus within the international scientific community in favor of sending a network of geophysical landers to Mars to characterize the near-surface weather and climate, determine the large-scale atmospheric dynamics and explore the interior structure and composition [e.g., 1-18]. Despite this scientific support, there has been an unbroken string of proposed missions over the past fifteen years which have failed for programmatic reasons to progress beyond the design stage (Mars Network Mission, MESUR, Marsnet [8], InterMarsnet [9], NetLander [19]). In this presentation, we review the scientific rationale and technical requirements for such a mission, and discuss current activities aimed toward its implementation.

Science Rationale: Although many types of investigations that might benefit from measurements at multiple locations on the surface of Mars, a network mission is essential to enable investigations that require simultaneous, spatially separated measurements. These capabilities are crucial for addressing first-order questions about the origin, evolution, environment and habitability of Mars.

Interior structure. A network of landers would probe the interior of the planet through seismic monitoring, magnetic sounding, and measurements of its rotational dynamics. This would allow the determination of the overall interior structure, including crust, mantle, and core divisions, the state of the core (liquid/solid, density). It would also provide information to infer density and elastic constants of the mantle which in turn lead to strong constraints on its composition, mineralogy and temperature profile. These are key aspects of understanding the formation and evolution of the planet in terms of its accretion, differentiation and subsequent convection history, as well as the planet's internal engine driving volcanism, tectonics and the delivery of endogenic volatiles to the surface.

Atmospheric circulation. The second primary task of such a mission would be to study the near-surface weather and climate, and the global and regional dynamics of the atmosphere. Simultaneous measurements of pressure, temperature, humidity, opacity and winds across the globe would allow the detailed investigation of the relationship between the circulation and its forcing These measurements are essential for characterizing the temporal and spatial structure of the atmospheric general circulation and the present-day climate, as well as the transport and deposition of dust and volatiles. They would also facilitate the interpretation of aeolian modification of surface features, so that the geomorphic record can be accurately interpreted to yield improved constraints on the past climate.

Environment and habitability. A network mission can also make significant contributions to the broader exploration goals for Mars. Meteorological measurements in the Martian planetary boundary layer are critical from an operational standpoint, because this will be the working environment for future landers, rovers, and manned missions to Mars. Similarly, surface radiation is an important environmental factor, and long-term measurements could easily be made at each station. The NetLander mission design showed that such stations (with, for example, beam-steerable GPR and passive EM sounding) can be used to search for water at depth, and other simple analysis packages could be considered in order to reconnoiter for other resources.

Technical Requirements: There are a number of high-level requirements that are peculiar to a geophysical network mission. The key requirement, of course, is for the simultaneous operation of multiple spacecraft on the surface. Whereas a minimum of four stations are required to meaningfully address most of the highest priority objectives, at least 20 would be needed to completely satisfy the scientific requirements. (Fewer than four stations could provide useful reconnaissance information, but would not be able to address many of the objectives described above). These stations must be long-lived in order to obtain a sufficient body of data, with a lifetime of at least one full Martian year, preferably with near-continuous operation. They must also have the capability of returning large volumes of data to the Earth, of the order many 10s of Mb per sol for each station.

These requirements have serious implications for various spacecraft resources, including power, mass, and cost. However, through numerous cycles of mission design studies, these challenges have been shown to be manageable. For the past fifteen years, the insurmountable problems have consistently been programmatic in nature.

Current Activities: It is clear that despite a vigorous international program of Mars exploration, many high-priority goals for understanding the origin, evolution, environment and habitability of Mars remain unmet. A geophysical network is clearly required to make the fundamental measurements necessary to address these questions. A large group of scientists remains committed to the goal of deploying an geoscience observatory network on Mars. Due to the broad interest in these data sets and the difficulty for any single space agency to finance this project, there is a strong consensus within this group that such an undertaking should done as an international collaboration. A workshop in Berkeley devoted to planning for a network mission that was held in the spring of 2004 attracted over 35 scientists from six countries. Around the same time, over 100 scientists from all over Europe met in Cologne to draft a proposal to ESA for undertaking a Mars network mission, and a consortium of 17 French research laboratories submitted a proposal to CNES to support a significant role in a Mars surface mission in the 2011 time frame. This latter proposal was selected for a Step 2 study, with a final downselection in 2006. Current efforts are underway to convince NASA to include a network mission in its plans, either through a proposal (with major international contributions) to the Mars Scout program or as part of the new exploration initiative. It is anticipated that the data from such a mission would be made freely and quickly available to the entire world science community.

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