AN AUTONOMOUS INSTRUMENT PACKAGE FOR PROVIDING "PATHFINDER" NETWORK MEASUREMENTS ON THE SURFACE OF MARS. W. B. Banerdt[1] and Ph. Lognonné[2], [1]Jet Propulsion Laboratory, California Institute of Technology (Mail Stop 183-501, 4800 Oak Grove Drive, Pasadena, CA 91109, bruce.banerdt@jpl..nasa.gov), [2]Institut de Physique du Globe de Paris (Departement de Géophysique Spatiale et Planétaire, 4 Avenue de Neptune, 94100 Saint Maur des Fossés, France, lognonne@ipgp.jussieu.fr).

Introduction: The investigations of the interior and atmosphere of Mars have been identified as high scientific priorities in most planetary exploration strategy document since the time of Viking [e.g., 1,2]. Most recently, the National Academy of Sciences [3] has recommended a long-lived Mars network mission as its second highest scientific priority for Mars (after sample return) for the purpose of performing seismological investigations of the interior and studying the activity and composition of the atmosphere.

Despite consistent recommendations by advisory groups, Mars network missions (MESUR, Marsnet, InterMarsnet, NetLander/MSR'05, NetLander/Premier '07, NetLander/??'09) have undergone a strikingly consistent "Phoenix" cycle of death and rebirth over the past 15 years, and there are still no confirmed plans to address the interior and atmosphere of Mars. The latest attempt is the NetLander mission [4]. The objective of NetLander is to place a network of four landers on Mars to perform detailed measurements of the seismicity and atmospheric pressure, temperature, wind, humidity, and opacity (as well as provide images, subsurface radar sounding profiles, and electric/magnetic field measurements). However, this mission has recently encountered major programmatic difficulties within CNES and NASA. NASA has already cancelled its participation and the mission itself is facing imminent cancellation if CNES cannot solve programmatic issues associated with launching the mission in 2009.

In this presentation we will describe an approach that could move us closer to realizing the goals of a Mars network mission and will secure at least one geophysical and meteorological observatory in 2009.

Network "Pathfinder": Many of the problems in implementing a large-scale, expensive network mission derive from the uncertainties inherent in making an entirely new type of observation. Meaningful seismic measurements have never been obtained on Mars. The Viking seismometers [5] provided only a loose upper bound on the seismic activity of the planet [6], which could still be several orders of magnitude more active than the Moon. Thus we have no firm idea as to the size, frequency, distribution, or signal characteristics of Martian seismic events, or of the character of any seismic noise that must be dealt with (although theoretical estimates exist [7,8]). Such uncertainties make it difficult to efficiently design a network mission, and indeed provide pause when contemplating the investment required.

The technical demands on the instruments and lander subsystems for a long-lived network are considerable. They must operate continuously for long periods of time (several years) in an extremely cold environment with huge daily and seasonal temperature variations. They must be able to store, compress and transmit large quantities of data (over 300 Mbits of raw data per sol). And the resources available will likely be extremely limited, as the mass and volume will be minimized in order to allow the maximum number of stations to be launched.

Thus there are a number of arguments for sending a single station to Mars to acquire reconnaissance data for designing a large-scale network investigation and to validate the instrument and subsystem technology. In addition, whereas the observations of a single station will not satisfy the goals of a global network for delineating the interior structure and atmospheric circulation, it can provide scientifically meaningful results in many areas, including the present level of tectonic activity, boundary layer processes and surface-atmosphere interactions, and local meteorology.

Autonomous Package: We envision an autonomous package that could easily be left on the surface by any lander mission. Clearly the best candidate at this time is the Mars Science Laboratory (MSL), scheduled for launch in 2009. That mission currently does not include any geophysical or meteorological measurements in its baseline, so this package would complement that mission with very little impact. The addition of a small camera could further enhance MSL by providing the capability of imaging the rover, which may be useful for both engineering and public outreach.

The package would be self-contained with its own power, data handling, and communications systems. The mass would be minimized (perhaps ~10 kg) so as to make the least possible impact on the carrier spacecraft. Our description here is base on the NetLander experience. These instruments and lander subsystems are currently approaching PDR, so there is considerable maturity in their designs.

Instruments. The instruments in this package would include, at a minimum, a broadband seismometer and a meteorology package. Other instruments could be added if resources allow, but the premium placed on low mass and volume make this problematic.

The seismometer [9] consists of two types of sensors in order to cover the entire seismic frequency range with maximum sensitivity. There are two VBB (Very Broad Band) sensors which are enclosed in a leveled, environmentally controlled container. These have a leaf spring and pivot configuration with capacitive and OCS transducers. They provide measurements of ground acceleration in the vertical and one horizontal axis to a level of 10^{-10}m/sec^2 over a frequency range from micro-Hertz (corresponding to tidal frequencies) to a few Hertz. Three orthogonal SP (Short Period) sensors are mounted directly to the deployment device (for better high-frequency coupling) and will measure the full vector ground acceleration to a level of 5×10^{-9} m/sec^2 from 0.05-100 Hz. These microseismometers utilize advanced silicon micromachining technology to achieve high sensitivity with extremely low mass, power, and volume.

The meteorology package [10] consists of pressure and humidity sensors, along with a mast containing a wind velocity sensor and temperature sensors located at several levels. The height of the mast will depend on the dimensions of the package, but ideally would be at least 1.5 m. This package will allow the characterization of diurnal variations of temperature, pressure, humidity, and wind, as well as the short-scale phenomena associated with vertical energy flux and the interaction of the atmosphere with the surface[11].

Communication and power. Communication would be via orbital relay only, with no direct-to-Earth link. There are several assets planned for Mars orbit in the next 6-10 years which could accommodate a low-power UHF link from this package. In particular, the Mars Telecommunication Orbiter planned for launch in 2009 would strongly enhance the data volume available from this package. It is also possible that high-precision geodetic measurements can be performed with proper specification of the package's telecom subsystem.

At this time, a solar array is the only long-lived power source that is available for use on the Martian surface. This has the disadvantages of a limited latitude range, decreased power in the winter (when heating requirements are greatest), and degradation over time by dust deposition. This package (and any long-lived network that may follow) would greatly benefit from the availability of a small radioisotope generator in the <10W class.

Conclusions: A small, autonomous package taken to the Martian surface by MSL could provide valuable scientific information on the seismicity and atmospheric processes on Mars, as well as provide pathfinder information for a future long-lived network mission. Leveraging from the technical designs and partnerships developed by the NetLander mission might save cost and reduce risk. This package could provide the first of a series of geophysical and meteorological observatories on Mars.

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