MARS PATHFINDER MISSION AND SCIENCE INVESTIGATIONS

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Mars Pathfinder is one of the first Discovery class missions, which are quick, low-cost projects with focused science objectives. It will land a single vehicle with a microrover and several instruments on the surface of Mars in 1997. In addition to demonstrating an inexpensive system for cruise, entry, descent, and landing on Mars, it will deploy and operate a microrover and three science instruments: a stereoscopic imager with visible through near infrared filters on a pop up mast, an alpha proton x-ray spectrometer (APXS), and an atmospheric structure instrument/meteorology package. This payload provides the opportunity for carrying out a variety of scientific investigations, including surface morphology and geology at meter scale, elemental composition and mineralogy of surface materials and a variety of atmospheric science investigations.

The Pathfinder flight system is an aerocraft consisting of a simple back-pack style cruise stage, with solar arrays, an antenna and propulsion system; deceleration subsystems, including an aeroshell, backcover, parachute, small solid rockets and airbags; and a tetrahedron-shaped lander packaged within the aeroshell and backcover. The spacecraft enters the martian atmosphere directly from an Earth-Mars transfer trajectory and is slowed by the aeroshell and parachute. The lander is lowered on a tether below the backcover and parachute. Prior to landing, three small solid rockets fire, the airbags inflate, and the tether is cut. The airbags absorb the final horizontal and vertical velocity. After landing, the airbags are deflated and the triangular petals open, righting the lander, exposing solar panels and allowing the rover to drive off. The lander is capable of surviving for at least 30 sols, with a possible lifetime of up to a year. The current spacecraft launch mass is approximately 850 kg, including 25 kg of surface payload (science instruments, rover, and rover support equipment).

The rover on Mars Pathfinder is a small (10 kg), six wheel drive rocker-bogie design vehicle, 65 cm long by 48 cm wide by 32 cm high. It is a solar-powered vehicle that operates almost entirely within view of the lander cameras, or within a few tens of meters of the lander. The payload consists of monochrome stereo forward cameras for hazard detection and terrain imaging and a single rear color camera. Also on the rear of the vehicle is the APXS mounted on a deployment device that will place the APXS sensor head against both rocks and soil. The rear-facing camera will image APXS measurement sites with 1 mm resolution. The rover will perform a number of technology experiments designed to provide information that will improve future planetary rovers. Experiments of interest to scientists include: terrain geometry reconstruction from lander/rover imagery; basic soil mechanics by imaging wheel tracks and wheel sinkage; material abrasion by sensing abrasion of different thicknesses of paint on a rover wheel; and material adherence by measuring dust accumulation on a reference solar cell with a removable cover and by directly measuring the mass of the accumulated dust on a quartz crystal microbalance.

The surface imaging system will reveal martian geologic processes and surface-atmosphere interactions at a scale currently known only at the two Viking landing sites. It will observe the rock distribution, surface slopes and general physiography in order to understand the geological processes that shaped the surface. This will be accomplished through panoramic stereo imaging at various times of the day as well as before and after the imager deploys on its mast. Images will be calibrated by observing a flat field target near the camera head and shadowed and illuminated portions of reference test charts on the lander. In addition, observations over the life of the mission will allow assessment of any changes in the scene over time that might be attributable to frost, dust or sand deposition or erosion or to other surface-atmosphere interactions. A basic understanding of near-surface stratigraphy and soil mechanics will be obtained by lander and rover imaging of rover tracks, holes dug by rover wheels, and any surface depressions produced during landing of the spacecraft.

The APXS and the visible to near infrared (0.4 to 1 micron) filters on the lander imaging system will determine the elemental composition and constrain the mineralogy (particularly pyroxene and iron oxides) of rocks and other surface materials, which can be used to address questions concerning the composition of the crust, its differentiation and the development of weathering products. The APXS sensor head will be placed on rocks, soil surfaces, in holes dug by the rover wheels and against rocks that have been attempted to be abraded by a rover wheel. Multispectral images of 5 sets of magnetic targets distributed at various points (and heights) around the spacecraft will discriminate the magnetic phase of accumulated airborne dust. In addition, APXS measurement of magnetic targets in the rover ramps will determine the titanium content of the dust, which is critical for discriminating the various magnetic phases. A rear-facing camera will enable close-up images with millimeter resolution of every APXS measurement site. With these images and auxiliary information from lander imaging spectra of APXS measurement sites, it is likely that mineralogy can be constrained from the elemental abundances measured by the APXS.

The atmospheric structure instrument will determine a pressure, temperature and density profile of the atmosphere (with respect to altitude) during entry and descent at a new location, time and season (landing will occur in southeast Chryse Planitia, 600 km from Viking Lander 1, just before sunrise in late northern summer). Measurements of pressure and temperature will be made in a triangular space between the petals at the base of the lander during descent. Redundant three-axis accelerometers will allow extraction of atmospheric density profiles and hence pressure and temperature profiles during entry. Diurnal variations in the atmospheric boundary layer will be characterized by regular surface meteorology measurements (pressure, temperature, atmospheric opacity, and wind). Three thermocouples will be mounted on a meter high mast located on a petal away from the thermally contaminating lander electronics to determine the ambient temperature profile with altitude. A wind sensor on the top of this mast along with 3 wind socks below it will allow determination of wind speed and direction versus altitude in the boundary layer as well as calculation of the aerodynamic roughness of the surface. Regular sky and solar spectral observations by the lander imager will also monitor dust particle size and shape, refractive index, vertical aerosol distribution and water vapor abundance.

The Pathfinder landing site is constrained to be within ±5° of 15°N so that the lander and rover solar arrays can generate the maximum possible power (sub-solar latitude at landing is 15°N; late northern summer) and to facilitate communication with Earth (sub-Earth latitude is 25°N). The altitude of the site must be below 0 km so that the descent parachute has sufficient time to reliably open and slow the lander to the correct terminal velocity. Landing will occur within a 100 by 200 km ellipse with a N74E trending semi-major axis due to navigational uncertainties during cruise and atmospheric entry.

An open workshop, the "Mars Pathfinder Landing Site Workshop" attended by over 60 interested scientists and engineers from around the United States and Europe, was held April 18-19, 1994 at the Lunar and Planetary Institute in Houston, Texas [1] to solicit ideas from the science community on potential landing sites. Presentations included a description of the mission, spacecraft and instruments, general landing site perspectives from a variety of disciplines, data pertaining to landing site safety, and over 20 proposed individual landing sites. Analysis of virtually all available data and models including: Viking images, thermal inertia, rock abundance, albedo, radar, color, occultation data, and weather data from Viking measurements and atmospheric models were made after the workshop on a prioritized subset of the proposed sites. Final selection was made at the June 9-10, 1994 meeting of the Mars Pathfinder Project Science Group.

The Pathfinder Landing Site selected is Ares Vallis (19.5N, 32.8W, -2 km elevation), where a catastrophic flood channel debouches into Chryse Planitia. This site is a "grab bag" site with the potential for sampling a wide variety of different martian crustal materials, such as Noachian plateau material (aka, ancient crust) as well as Hesperian Ridged Plains and a variety of reworked channel materials. Even though the exact provenance of the samples would not be known, data from subsequent orbital remote sensing missions could then be used to infer the provenance for the "ground truth" samples studied by Pathfinder. Available data suggest the site is about as rocky as the Viking sites, but perhaps a bit less dusty [2]. This site has streamlined islands nearby and a very smooth depositional surface at Viking resolution (order 40 m/pixel), except for large (hundreds of meters) blocks or hills and small secondary craters.

References: [1] Golombek, M., ed. (1994) *Mars Pathfinder Landing Site Workshop*, LPI Tech. Rep. 94-04, 1994, 49pp. [2] Golombek, M., T. Parker & H. Moore, 1995, Mars Pathfinder Landing Site Characteristics: Lunar Plan. Sci. XXX, this volume.