THE GOALS AND APPROACH OF THE PHOENIX MISSION FOR EVALUATING THE HABITABILITY OF THE NORTHERN PLAINS ON MARS. C. R. Stoker[1] [1]Space Science Division, NASA Ames Research Center, Moffett Field, CA 94035, carol.r.stoker@nasa.gov. Submitted to Fourth International Conference on Mars Polar Science and Exploration, Abstract 8076, 2006.

Introduction: The first goal of the Mars Exploration program, as defined by the Mars Exploration Payload Analysis Group (MEPAG) is to determine if life ever arose on Mars [1]. The Phoenix landing site was chosen to sample near surface ground ice in the Northern Plains discovered by the GRS experiment on Mars Odyssey [2]. A goal of Phoenix is to determine whether this environment was habitable for life at some time in its history.

Evaluation of Habitability: Given our current understanding of life, the potential for habitability in a specific time and space encompasses three factors: (1) the presence of liquid water (P_{lw}), (2) the presence of a biologically available energy source (P_e), and (3) the presence of the chemical building blocks of life (e.g. C, H, N, O, P, S) in a biologically available form, or a transport mechanism for them to the habitable environment (P_c). Since these three factors must be simultaneously present, MEPAG [1] proposed a Habitability Index, HI= 100 * $P_{lw} P_e P_c$, which is the product of the probability represented by each of the three factors, and further suggested that a life detection mission could not be justified unless a previous mission had determined HI to have a combined probability greater than 50. Thus a quantitative evaluation of habitability is a precursor requirement for sending a mission to search for life. I will present a method for quantitatively evaluating HI for the Phoenix landing site. Each of the above probabilities can further be decomposed into sub-elements or observables that combine for its evaluation. P_{lw} is most amenable to quantitative evaluation and has greatest variation with location on Mars. It is comprised of three factors: F_o, observations (chemical or morphological) that suggest liquid water; F_{ice}, the presence and age of ice; and F_{th}, theoretical models that show ice melting is possible. Each factor is assigned a value from 0-1 and a weighting factor to evaluate its relative weight compared with the other factors. The probability is then the weighted sum of the factors. A similar approach can be used for evaluating the other probabilities.

Modern liquid water at the Martian surface, should it occur, would be an important factor in the potential habitability of the environment. In the current epoch, conditions in the Northern Plains never reach the triple point pressure and temperature, the point of thermodynamic stability of pure liquid water. Unlike at the corresponding latitudes in the Southern hemisphere, in the low elevation Northern Plains, pressure is above the triple point but the solar flux is not strong enough to warm the surface above 0C. However, climate modeling studies [3, 4] show that the Northern plains experience strong variations in the incident solar insolation due to variation of orbital parameters. Importantly, the solar longitude of perihelion and the obliquity both vary on Mars, and the solar flux at the Phoenix landing site has varied by over a factor of three during the last million years. Only 25,000 years ago, solar forcing at the Phoenix landing site was strong enough that triple point conditions were exceeded up to

50 days a year[4] and many such warm periods have occurred in the last million years. These warmer conditions caused much greater evaporation of water from the Northern cap, possibly resulting in snowfall that may have been an emplacement mechanism for near surface ground ice [3]. The melting of snow, or the melting of the ground ice itself, may have resulted in liquid water.

Phoenix Observations Relevant to Evaluating Habitability: In order to evaluate HI, a mission payload must provide information relevant to evaluating the three probabilities and the Phoenix payload is highly relevant for this purpose. Imaging systems on Phoenix provide spatial resolution ranging from nanometer to decameter scales, allowing an identification of landforms and morphology of ice and soil that may indicate alteration by liquid water. Microscopic imaging of ice collected by the Robotic Arm may identify evidence that melting has occurred in ground ice. The percentage of ice in the soil (as measured by TEGA) could also indicate that melting has occurred since ice deposited in the soil from atmospheric vapor transport would not exceed the pore volume. Older ice is more likely to have experienced warm conditions than recently emplaced ice. The isotopic ratio of Oxygen (also a TEGA measurement) could provide a determination of the age of the ice sampled by Phoenix. Additional information about the age of the surface will be obtained from an evaluation of the geomorphology of the landing site using the SSI and RAC imaging systems. The MECA experiment measures the soluble ions in the soil and thus provides information about whether the biogenic elements are available in a biologically accessible form. Finally, a most exciting prospect is that Phoenix has the ability to measure organic compounds with the TEGA instrument. If episodic modern liquid water occurs, it is possible that the landing site is not just habitable but that life persists and grows when conditions are right. If so, then organic compounds would be produced during periods of growth and these may be preserved within the ice.

In summary, Phoenix will land at a location on Mars with a high potential for habitability and will sample the icy material most likely to host a record of modern biological activity with a payload selected to provide key information about the potential habitability of this environment. Phoenix is thus an important mission in pursuit of the goal of searching for life on Mars.

References: [1] Beatty, D. (ed.) MEPAG Goals Doc., Feb. 2006; Steele, A. and Beaty, D. , Findings of the Astrobiology Field Lab Science Steering Group, MEPAG Doc. April, 2004. [2] Feldman, W.C. *et al., Jour. Geophys. Res.* 109, E09006, 2003JE002160, 2004. [3] Haberle, R. *et al., EOS Trans. Amer. Geophys. Union*, San Francisco, 2003. [4] Richardson M. and M. Michna, *Jour. Geophys. Res.* 110, EO3003, 2004JE002367, 2005.