LANDING SITES PROPOSED FOR THE MARS SCIENCE LABORATORY MISSION. M. Golombek[1], J. Grant[2], A. R. Vasavada[1], and M. Watkins[1], [1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, [2]Smithsonian Institution, Washington, D.C. 20560.

Introduction: The Mars Science Laboratory (MSL) mission is a long-range rover with an analytical laboratory that is being developed for launch in 2009. The spacecraft will land in a small ellipse less than 20 km in diameter with the capability to carry out detailed geology, mineralogy, geochemistry and organics investigations. It carries a sophisticated sample acquisition and processing system for obtaining key samples for the analytic instruments to search for and assess habitable environments. Science objectives for the mission, planetary protection considerations, engineering constraints for the mission, and a description of the schedule and open landing site workshops have been described by Golombek et al. [1]. This abstract discusses the landing sites proposed and prioritized at the First Mars Science Laboratory Landing Site Workshop, changes to engineering constraints since the workshop, imaging of the sites by orbiting spacecraft, and plans for the Second Landing Site Workshop.

First Workshop Results: The First Mars Science Laboratory Landing Site Workshop was held May 31-June 2, 2006 in Pasadena, California. The purpose of the workshop was to identify and evaluate potential landing sites best suited to achieving mission science objectives within the constraints imposed by engineering and planetary protection requirements and the necessity of ensuring a safe landing. Engineering constraints allowed the consideration of an enormous number of landing sites over ~70% of Mars because of the small landing ellipse (20 km), and broad latitude (±60°) and high elevation (+2 km) constraints. These constraints were posted before the workshop on web sites that also include abstracts, presentations, reports and results (including the list of landing sites proposed) [2].

The workshop was well attended with about 100 participants that included Principal and Co-Investigators from MSL, Principal and Co-investigators from major orbiter instruments that are being used to certify the sites, and many scientists unaffiliated with MSL, which highlights the Mars community's interest in MSL landing site activities. A wide variety of sites were proposed at the workshop. A total of 33 general sites were proposed that incorporated 94 landing ellipses (multiple ellipses were proposed for some sites) that span a considerable range of latitudes and elevations on Mars (Figure 1). Most landing sites were proposed based on morphology (e.g., layered or deltaic deposits) or mineralogy (e.g., sulfates or phyllosilicates from OMEGA, Observatoire pour la Mineralogie, l'Eau, les Glaces, et l'Activite [3]) indicative of aqueous processes or both. In addition to the landing site presentations, there was substantial discussion of their merits and a vote to prioritize the sites based on their science potential and safety for subsequent imaging. Sites prioritized in the top third (Figure 1) include 3 characterized by phyllosilicate signatures (Nili Fossae, Mawrth Vallis and Nilo Syrtis), 2 characterized by sulfate signatures (W. Candor and Juventae Chasma), with the rest characterized by layered deposits of likely or proposed aqueous origin. Most, but not all of the highest ranked two thirds of the sites are "go to" sites that have a safe landing site adjacent to the target of science interest that require traversing outside of the landing ellipse to sample the materials of highest interest.

The sites farthest north and south are at 23°N and 57°S, respectively, with all of the sites ranked in the top 50% falling between 23°N and 28°S. By contrast, all of the sites lie between +1 km and -4.5 km (MOLA, Mars orbiter Laser Altimeter datum) with all of the sites ranked in the top 50% falling below -0.4 km. Only one proposed site is located at an elevation above 0 km.

Changes to Engineering Constraints: The existing range of latitudes and elevations accessible by MSL was reevaluated after consideration of the locations of the sites proposed at the first workshop. For example, reducing the latitude limits to between ±45° latitude and elevation limits to less than +1 km would eliminate a total of 3 of the proposed sites from consideration. All three of these were ranked in the lowest third of the sites. Hence, some reduction in both the latitude and elevation range accessible to MSL could likely be accommodated with limited impact to the mission science return.

Following the workshop the Mars Science Laboratory Project conducted a complete review of the entry, descent and landing system and concluded that substantial savings in timeline and testing (and budget) could be realized if the elevation constraints were reduced to less than +1.0 km and thermal design and communications could be simplified if the latitude constraints were reduced to ±45°. NASA Headquarters approved these changes so that landing sites under consideration must now be below +1.0 km and within ±45° latitude. Other engineering constraints remain unchanged except for the addition of a requirement that

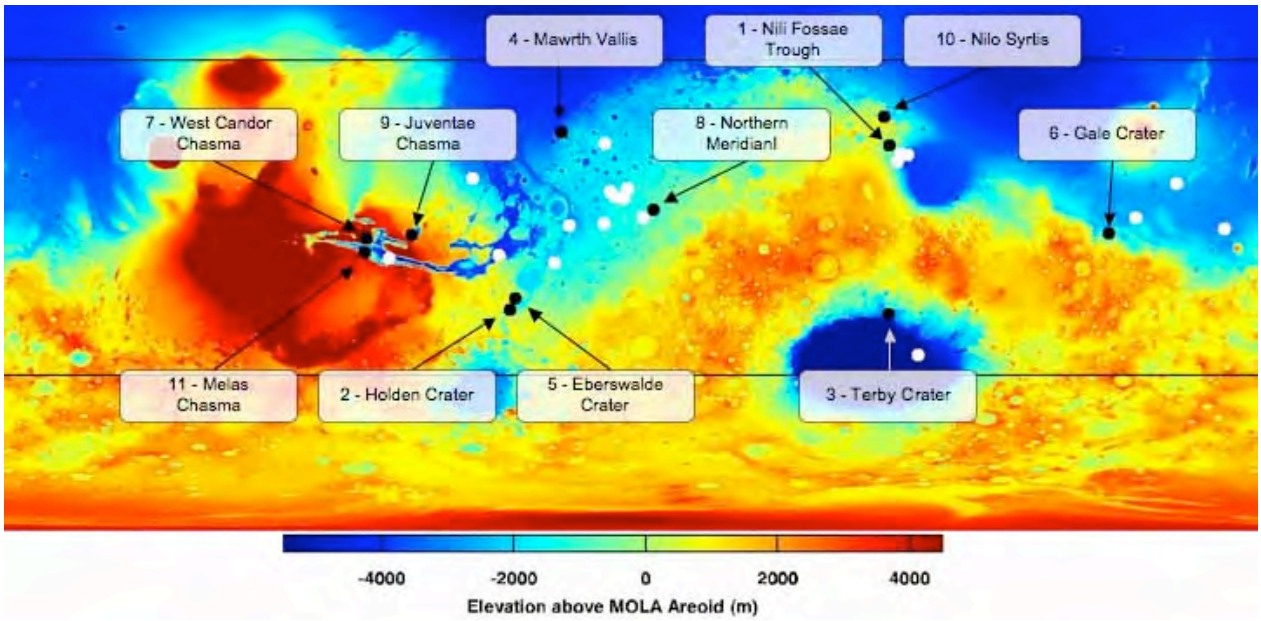

Figure 1: MOLA topographic map of Mars showing location of landing sites proposed for the Mars Science Laboratory at the first workshop that are within ±45° latitude (horizontal lines). Highest ranked third are in black and labeled; others are in white.

the slope over 200-500 m length scale be ≤5° to avoid altimetry errors in preparation for the sky-crane landing maneuver. In addition, the project has begun to evaluate the entire landing region against existing atmospheric engineering constraints, and over the next year will begin to focus on detailed modeling of individual sites.

Remote Sensing Targeting of Landing Sites: Of the 33 sites proposed and prioritized at the first workshop, 30 have been defined and targeted by remote sensing assets. For each landing site proposed, a single 20 km diameter ellipse has been defined that appears smooth and flat. In addition, a Region of Interest (ROI) has been defined that includes the landing ellipse and if it is a "go to" site, the area of interest for the rover to explore. Finally, each site includes the location of the preferred HiRISE (High Resolution Imaging Science Experiment) image for the standard survey images that are being acquired by Mars Reconnaissance Orbiter (MRO). The standard MRO survey images for MSL landing sites are a collocated set composed of: 6 km wide by 10 km long HiRISE image at 30 cm/pixel; 10 km by 10 km CRISM (Compact Reconnaissance Imaging Spectrometer for Mars) image at 18 m/pixel (512 bands); 30 km by 30 km CTX (Context Imager) image at 6 m/pixel. These locations have been input into HiRISE targeting software and provided to the rest of the MRO instruments. The locations have also been submitted to other orbiting imaging assets including Mars Global Surveyor, Mars Odyssey, and Mars Express. Images acquired of the landing sites are being posted at the following locations: Mars Orbiter Camera (MOC) images at http://www.msss.com/mars_images/moc/guest/; THEMIS (Thermal Emission Imaging System) images at http://themis.asu.edu; HiRISE images at http://marsoweb.nas.nasa.gov/HiRISE/hirise_images/; and HRSC (High Resolution Stereo Camera) images at ESA's Planetary Science Archive ftp://psa.esac.esa.int/pub/mirror/MARS-EXPRESS/HRSC/

Second Landing Site Workshop: The second workshop is planned for October 2007 (more than a year after the first) to give time to acquire new image and spectral data. This workshop will evaluate the proposed sites imaged by MRO and other orbiters and will develop a smaller, down-selected list of landing sites based on science (likely including both morphology and mineralogy from spectra) and safety. Additional image acquisition by MRO (with special attention to stereo coverage for quantitative evaluation of slopes) and other orbiters will allow a more detailed understanding of the science potential and safety characteristics of these sites. The Third Landing Site Workshop will be held 8/08 to recommend the 10º latitude by 15º longitude landing site zone within which the preferred ellipse will be identified. The Fourth Landing Site Workshop will be held 6/09 at which the final landing site and ellipse are recommended.

References: [1] Golombek et al. (2006) *Lun. Planet. Sci. XXXVII*, Abs. #2172. [2] http://marsoweb.nas.nasa.gov/landingsites/index.html and http://webgis.wr.usgs.gov/msl [3] Bibring J.-P. et al. (2005) *Science 307*, 1576-1581.