

**SELECTION OF FOUR LANDING SITES FOR THE MARS SCIENCE LABORATORY.** M. Golombek<sup>1</sup>, J. Grant<sup>2</sup>, A. R. Vasavada<sup>1</sup>, J. Grotzinger<sup>3</sup>, M. Watkins<sup>1</sup>, D. Kipp<sup>1</sup>, E. Noe Dobrea<sup>1</sup>, J. Griffes<sup>3</sup>, and T. Parker<sup>1</sup>, <sup>1</sup>Jet Propulsion Laboratory, Caltech, Pasadena, CA 91109, <sup>2</sup>Smithsonian Institution, National Air and Space Museum, Center for Earth and Planetary Sciences, Washington, D.C. 20560, <sup>3</sup>Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA 91125.

**Introduction:** Four landing sites were selected for the Mars Science Laboratory (MSL) after discussion of 7 downselected sites at the Third Landing Site Workshop and a subsequent project meeting. This abstract discusses the selection process, defines the sites under consideration, and describes subsequent activities to select the final landing site before launch in 2011.

A total of more than 50 landing sites/ellipses were proposed and targeted with Mars Reconnaissance Orbiter (MRO), Mars Odyssey, and Mars Global Surveyor observations after the First Landing Site Workshop in June 2006 [1]. The science merits of the sites relative to MSL objectives were discussed during the first and second landing site workshops. After the Second Landing Site Workshop in October 2007 and a Project meeting in December 2007, six landing sites (Nili Fossae trough, Mawrth Vallis, Holden, Eberswalde, Miyamoto and N Meridiani) were selected for further study and consideration [2].

#### **Consideration of Landing Sites Based on New**

**Data:** On July 8, 2008 the NASA appointed Mars Landing Site Steering Committee reviewed new data collected by MRO and other spacecraft since the 2<sup>nd</sup> workshop to ensure that new discoveries were considered in the process of identifying candidate MSL landing sites. Four new sites were submitted for consideration following a call to the Mars Landing Site Steering Committee, MRO Project Science Group (PSG), and the MSL PSG. These sites included: South Meridiani Planum (3.05S, 354.61E), Chloride (3.07S, 351.53E), Gale crater (4.49S, 137.43E), and Nili Fossae carbonate (21.69N, 78.85E).

After a two-week period to review the new sites, a telecon was held that included summary presentations of each site, safety concerns, and a discussion of the schedule and status of the site selection process. The 25 participants represented the Steering Committee, MSL PSG, NASA Headquarters, and individuals who had proposed the sites.

There was unanimous agreement that all four of the new sites were potentially equally or more compelling than the existing 6 sites. Moreover, phyllosilicates adjacent to the new S. Meridiani site coupled with no safety concerns led the group to conclude it was scientifically more compelling than the existing N. Meridiani site. Hence, the new S. Meridiani site was swapped for the existing N. Meridiani site. Limited diversity of geologic targets at the Chloride site was a concern. The Gale crater site, which includes a central mound with layered sulfates and phyllosilicates, was preferred by a two-to-

one margin over the Nili carbonate site. As a result, Gale crater was added to the existing list of sites under consideration. Supporting materials related to these new sites are posted at [3].

**Third MSL landing Site Workshop:** The Third Mars Science Laboratory (MSL) Landing Site Workshop was held in Monrovia, CA, September 15-17, 2008. The meeting was attended by approximately 125-150 participants; the main objective was to provide a general ranking of the sites based on science potential, with emphasis on defining the top third, middle third and bottom third.

Presentations were grouped into an introductory session followed by individual sessions for each of the seven sites remaining under consideration. The introductory session included presentations on how to apply the scientific objectives of MSL to Mars and the selection of the landing site. Ample time was provided for discussion of all sites and supporting materials related to all aspects of the workshop, including individual presentation materials, were posted in real time at [3].

All seven remaining sites clearly possess high science merit and were deemed by the MSL project to satisfy preliminary engineering criteria as currently understood. The seven sites include in order of presentation: Miyamoto crater, S. Meridiani Planum, Nili Fossae trough, Holden crater, Eberswalde crater, Mawrth Vallis, and Gale crater.

After all sites were presented and discussed, paper ballots were distributed that included 11 questions divided between four major mission-relevant landing site criteria: diversity, context, habitability, and preservation potential (with emphasis placed on diversity and context). Workshop participants were instructed to assign green (highest), yellow, or red (lowest) colors to each site for each of the questions with emphasis placed on using all color categories to maximize the ability to differentiate between sites.

Results of the voting were presented as both the mode (color receiving the most votes) and weighted average (assigning 5 points to each green vote, 3 to each yellow vote, and 1 to each red vote that were then summed and divided by the total number of votes). Both methods yielded similar results.

Eberswalde, Holden, and Gale craters were the three highest ranking sites based on science potential and were closely followed by Mawrth Vallis (ellipse 2) and Nili Fossae trough. Miyamoto crater and South Meridiani were the deemed to possess lesser relative science merit. Because both Eberwalde crater and Holden crater are

southern latitude sites that are sensitive to unresolved engineering concerns related to operations and mobility (not discussed at the workshop) it is reasonable to carry 4 sites forward: the top 3 and either Mawrth Vallis or Nili Fossae.

**MSL Project Meeting:** On November 5, 2008, representatives of the MSL project management, engineering, and science teams met with members of the external MSL Landing Site Steering Committee and selected review board members to discuss the engineering assessment of landing safety, traversability, and the current status of predicted actuator thermal performance, in order to combine this information with the science rankings from the 3<sup>rd</sup> workshop. Project resources and timeline allow only 3 or 4 sites to have the full data acquisition and detailed analyses required for final approval.

The Science Ranking from the 3<sup>rd</sup> community workshop and vetted without change by the MSL PSG was expressed in 3 groups from most preferable (Group 1: Holden, Eberswalde, Gale) to least preferable (Group 3: Miyamoto, S. Meridiani); with intermediate Group 2 (Mawrth, Nili). The Engineering Ranking (focused on entry, descent and landing risk) was divided into 2 groups: Group 1-most safe (Holden, Gale, Mawrth), Group 2-less safe (Eberswalde, risk still fairly low for portions of ellipse, but potential high slopes and rock

coverage issues in remainder of ellipse), and “Group 2.5” (Nili, highest risk site due to high altitude stressing parachute deploy mach number and general entry and descent timeline margin; some entry, descent and landing review board members found it to have nearly unacceptable overall risk).

By comparing the science and engineering groupings, it was clear that Holden and Gale are in Group 1 for both and should be finalists. Mawrth advanced next due to being in Group 1 engineering and Group 2 science. It was then decided that the 4<sup>th</sup> and final site to advance should clearly be the last “Group 1” science site, Eberswalde, due to its strong science value and be subject to further data acquisition and safety assessment. Therefore the final 4 sites selected for further analysis are: Holden, Gale, Mawrth (ellipse #2) [2], and Eberswalde.

**Future Events:** With the launch of MSL slipped to 2011, landing site selection will take place in late 2010 or early 2011. Initial planning considerations are for a

Fourth Landing Site Workshop in late 2009, an opportunity for sites with compelling new data to be added sometime in 2010, and a Fifth Landing Site Workshop in late 2010 before landing site selection. Additional announcements will be made on future events that include the science community and will be posted at [3].

**References:** [1]

Golombek et al. (2007) *LPS XXXVIII*, Abs. #1392. [2] Golombek et al. (2007) *XXXIX*, Abstract #2181. [3] <http://marsoweb.nas.nasa.gov/landingsites/> and <http://webgis.wr.usgs.gov/msl>

MSL LANDING SITES			
NAME	LOCATION	ELEVATION	TARGET
Holden Crater	26.37°S, 325.10°E	-1940 m	Fluvial Layers, Phyllosilicates
Mawrth Vallis (2)	24.01N, 341.03°E	-2246 m	Noachian Layered Phyllosilicates
Eberswalde Crater	23.86°S, 326.73°E	-1450 m	Delta, Phyllosilicate
Gale Crater	4.49°S, 137.42°E	-4451 m	Layered Sulfates, Phyllosilicates

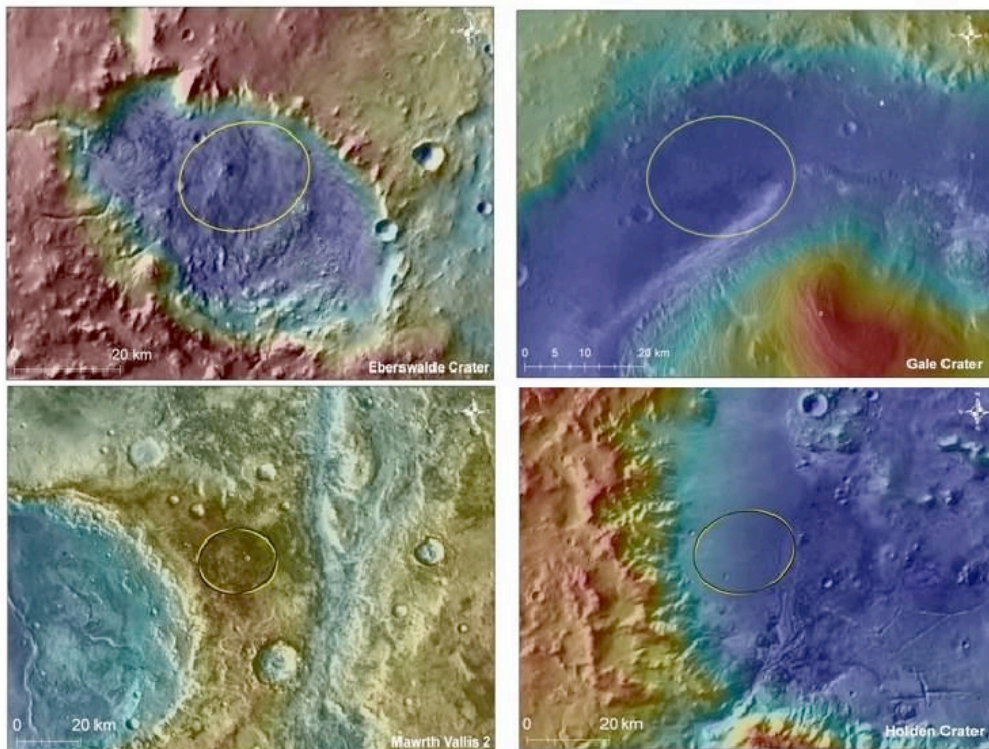


Figure 1: Four landing sites under consideration for the Mars Science Laboratory. Primary ellipses are 20 km by 25 km at coordinates in Table 1.