DOWNSELECTION OF LANDING SITES PROPOSED FOR THE MARS 2020 ROVER MISSION.

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Introduction: The Mars 2020 mission would explore a site likely to have been habitable, seek signs of past life, prepare a returnable cache with the most compelling samples, take the first steps towards in-situ resource utilization on Mars, and demonstrate technology needed for future human and robotic exploration of Mars. The first landing site workshop identified and prioritized 27 landing sites proposed by the science community according to science objectives that also met the engineering constraints [1]. This abstract describes the downselection of landing sites that occurred at the second landing site workshop and associated meetings.

Second Landing Site Workshop: The second Mars 2020 Landing Site Workshop was held in Monrovia, CA, August 4-6, 2015. The meeting was well attended, with between ~150-250 participants from the science community and the Mars 2020 project engineering and instrument science teams. The workshop included discussion of the science merits of 21 candidate landing sites that were presented at the workshop, and to provide a community ranking of the sites based on their science merits. This ranking would provide input to the Mars 2020 project to be considered with other factors (e.g. engineering, operations, planetary protection) to develop a list of ~8 sites that would remain under consideration.

Workshop presentations [2] were grouped into an introductory session summarizing current mission status and engineering assessments, and were followed by sessions grouping various candidate sites. Discussion of the sites included a rubric to help guide assessment of the candidate sites and the five scientific selection criteria (listed below) developed by the project that were used for voting [2].

1) The geologic setting and history of the landing site can be characterized and understood through a combination of orbital and in-situ observations. 2) The landing site offers an ancient habitable environment. 3) Rocks with high biosignature preservation potential are available and are accessible to investigation for astrobiological purposes with instruments on board the rover. 4) The landing site offers an adequate abundance, diversity, and quality of samples suitable for addressing key astrobiological questions if and when they are returned to Earth. 5) The landing site offers an adequate abundance, diversity, and quality of samples suitable for addressing key planetary evolution questions if and when they are returned to Earth.

Results of the voting were presented as the 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) and the mode (color receiving the most votes). This ensured that participants could not skew the results by withholding votes from some sites. Both methods yield similar results and reveal a fall-off in support for sites ranked lower than the top nine or ten based on mode and average, respectively [2]. The decreasing rank order of the average of the top ten sites is: Jezero crater, Columbia Hills, NE Syrtis, Eberswalde crater, SW Melas, Nili Fossae, Nili Carbonate, Mawrth Vallis, Holden crater, and McLaughlin crater.

Half of the top-ranked landing sites are deltaic environments (Eberswalde, Holden, Jezero, SW Melas and McLaughlin) reflecting the strong support in the science community that rocks in deltas are among the most favorable for recording signatures of possible ancient life. The other half of the top-ranked landing sites are in well exposed sections of ancient Noachian rocks that indicate a habitable environment (Jezero, Columbia Hills, NE Syrtis, Nili Fossae, Nili Carbonate, Mawrth, and McLaughlin), and several included Hesperian ridged plains (basalt), to calibrate the cratering time scale (Jezero, Columbia Hills, NE Syrtis, and Nili Fossae).

Joint Meeting: A joint Mars 2020 Project and Project Science Group, Mars Exploration Program, and the NASA appointed Mars Landing Site Steering Committee meeting was held immediately following the workshop. The purpose of the meeting was to discuss the top Mars 2020 landing sites and select eight sites for further engineering and science evaluation. Of the eight sites selected for further investigation, there is only one difference from the landing site workshop science ranking. The viability of the Nili Carbonate site depends on a significant reduction in landing ellipse that may not be realizable. In addition, the carbonate deposits at this site are available at other sites selected for further investigation. As a result, Nili Carbonate was replaced by the next highest ranked site (Holden). The eight sites selected are (in alphabetical order): Columbia Hills, Eberswalde, Holden, Jezero, Mawrth, NE Syrtis, Nili Fossae, and SW Melas (Fig. 1).

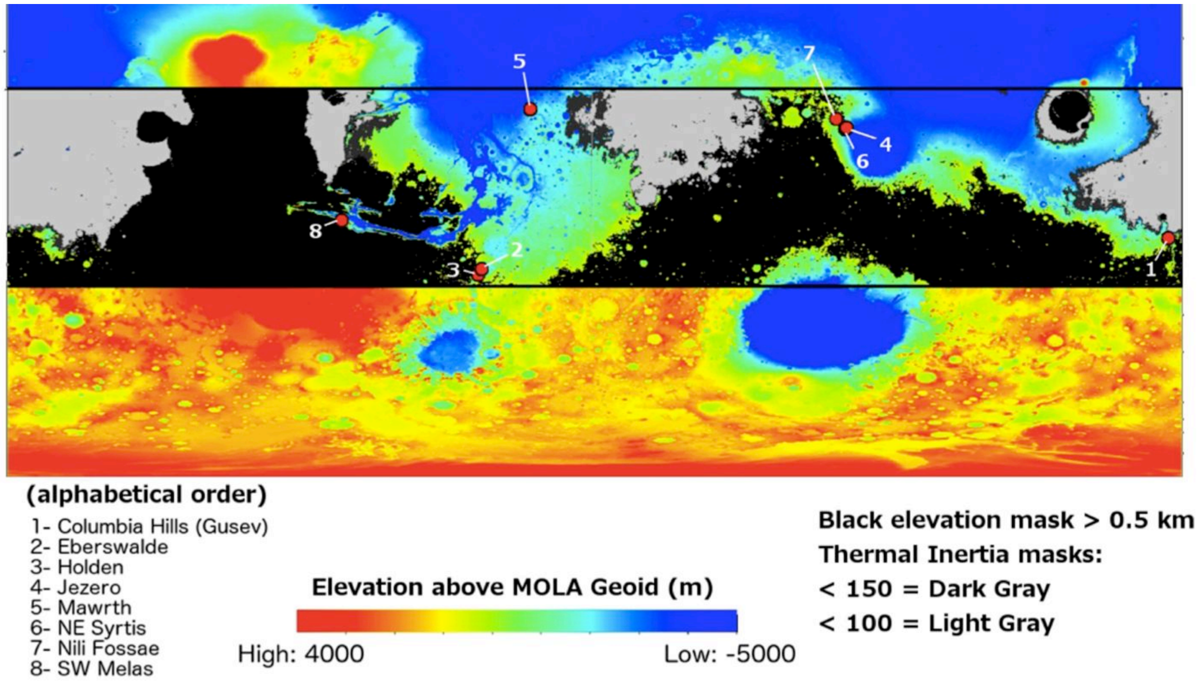

Figure 1. Topographic map of Mars showing the location of the 8 downselected landing sites, ±30° latitude band, elevation constraint, and low thermal inertia.

Further Analysis: The top eight sites are being assessed by the Mars 2020 Project. Additional HiRISE, CTX, and CRISM images of the landing sites have been requested from the Mars Reconnaissance Orbiter (MRO). CTX and HiRISE Digital Elevation Models [3] and HiRISE-based rock maps [4] are being produced to evaluate the need for Terrain Relative Navigation (TRN) being considered for the landing system, which provides the ability to avoid areas of <150 m radius that violate the slope and rock constraints within the ellipse [1], so long as they are surrounded by areas >100 m radius that appear safe for the landing system. In addition, traversability analyses are being carried out to determine how long it takes to traverses to Regions of Interest (ROI), where sampling would occur.

Initial landing simulation results for the sites have helped identify optimal ellipse placements and these locations have been confirmed with site proponents to produce a list of ellipse locations (Table 1). In addition, each site proponent has proposed the most important ROIs that would achieve mission science objectives when visited and sampled by the rover. These help to portray the likely distribution of exploration targets and aid in initial traversability analyses.

Table 1. Location and elevation of centers of 8 MSL landing ellipses 16 km by 14 km oriented east-west.

Site	Latitude, °N	Longitude, °E	Elevation MOLA, km
Columbia Hills	-14.590	175.534	-1.89
Eberswalde	-23.858	326.814	-1.44
Holden	-26.417	325.201	-2.16
Jezero	18.389	77.541	-2.62
Mawrth	23.955	340.940	-2.30
NE Syrtis	17.890	77.159	-2.03
Nili Fossae	21.023	74.239	-0.68
SW Melas	-9.805	283.584	-1.90

Preliminary engineering analyses show that TRN is required to guarantee access to five of the top eight sites. Three of the landing sites (Nili Fossae, Columbia Hills, and Holden) appear to be accessible safely without TRN. However landing at any of the sites with deltaic environments appears to require TRN.

Plans: Additional engineering analysis of landing safety at the sites, the time required to traverse and sample at ROIs, and additional characterization of the surface, including DEMs and rock maps of existing and newly acquired images, will proceed over the next year. In addition, more in depth scientific analysis of the sites, the materials present and how well they can address the science objectives of the mission, will also be carried out. The goal is to discuss this work at the Third Mars 2020 Landing Site Workshop scheduled in early 2017. Current plans are to further downselect to about four final landing sites soon after the workshop.

References:

[1] Golombek, M. et al. (2015) 46th LPS, Abstract #1653, [2] http://marsnext.jpl.nasa.gov/index.cfm. [3] Howington-Kraus, E. et al. (2015) 46th LPS, Abstract #2435, [4] Golombek, M. et al. (2012) Mars 7, 1-22.