Title: Discovery-class missions for Mars surface exploration
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Co-authors: This work was inspired by the effort led by Paul Niles to produce a white paper on multiple low cost missions for Mars exploration. Paul reviewed an earlier version of this work, but I have not asked for him or others involved with his effort to add their names to this work as of yet.
Summary: Discovery-class landed missions give the Mars community a capable and flexible vehicle to nimbly respond to mission opportunities in the next decade and continue exploration of the diverse science targets Mars has to offer.
Status and collaboration: The general thesis and core content of the white paper is presented below, but I welcome content additions and edits to strengthen the message of the paper. The amount of editing and additions would dictate the schedule to complete the white paper before the July 4 deadline. I am open to combining it with other, similarly-themed white papers to produce a single, stronger case.

Twenty-five years of the Mars Exploration Program (MEP) have revealed the extraordinary geologic record of Mars. Discoveries from each mission built on one another, feeding the science goals of subsequent missions, and eventually resulting in the confidence and knowledge base to undertake the process of Mars sample return (MSR). But a parallel outcome of dedicated and systematic Mars exploration is development and refinement of a host of scientific lines of inquiry that can most effectively be addressed by focused in-situ exploration of Mars. Examples include determining the habitability of the ancient Martian crust (e.g., Northeast Syrtis, Ehlmann and Mustard, 2012), constraining the history of water (and the climate implications of that history) at sites with significant geomorphological and/or mineralogical evidence of water detected from orbit (e.g., Mawrth Vallis, Poulet, 2005), and testing the hypothesis of potential biosignatures at Columbia Hills (e.g., Ruff et al., 2011). Indeed, the landing site workshops from MER, MSL, and Mars 2020 demonstrate there is no shortage of compelling scientific targets and questions that would benefit from focused in-situ exploration efforts. Investigating these sites and questions not only contributes to NASA and MEP goals, it deepens our detailed understanding of Mars as a system, which provides critical context for the most comprehensive interpretation of, returned samples.

The diversity of sites and the science questions therein warrant more access to the Martian surface, but to realistically achieve and sustain more access, it must be attained with missions smaller than the flagship missions employed by the MEP. Pursuit of Mars exploration with cubesat and SIMPLEx-level missions has begun, but the Discovery program represents a mature program and consistent opportunity already available for Mars mission proposals. Compelling science can feasibly be achieved by orbital missions under the Discovery cost cap; however, landers or rovers to the Martian surface within the Discovery cost cap have not yet been demonstrated without the benefit of pre-existing or significant percentages of contributed hardware. Discovery-class landers and rovers for Mars offer an exploration platform more robust to the challenges of the next decade including continuing Mars exploration in parallel with MSR efforts, defining the nature of Mars exploration beyond MSR efforts, balancing Mars exploration with other exploration priorities in the Solar System, and a changing paradigm for the MEP (e.g., JPL bringing Mars exploration under the broader umbrella of planetary science exploration).

Implementation specifics of a Discovery-class lander or rover on the Martian surface will be mission-dependent, but general guidelines can be set for such missions based on past experience. Missions envisioned for these opportunities are not sensitive to a particular launch date, but can achieve their scientific objectives utilizing regular launch windows (every 26 months). Nominal mission durations depend on the mission concept, the landing site, and the exact science goals and objectives of each mission. Lander-based missions (e.g., geochronology) are amenable to shorter nominal surface missions (e.g., 90-180 sols). A rover accessing a site with "land on" science (e.g., Mawrth Vallis) could explore high priority sites over a moderate nominal surface mission (e.g., one Earth year), while a rover accessing a site with "drive-to" science would require a longer nominal mission time (e.g., one Mars year) to balance in-situ exploration with traverse time. In all cases, longer mission durations will increase the science return. Certain spacecraft capabilities broadly support the ability of the science payload to achieve its goals, including a robotic arm, surface preparation tool, and articulated mast. If science cameras cannot be used for engineering support, the lander or rover would require inclusion of engineering cameras for operations such as navigation and instrument placement. Fitting under the Discovery cost cap is aided by knowing the landing site and its related science goals and objectives *a priori*, which permits selection of a focused science payload tailored to interrogate a given site.

The MEP series of flagships missions has matured Mars science to the point where we can pose critical science questions with smaller, focused missions. To advance the MEP into the coming decade, NASA must use the Mars Technology Program to develop Discovery-class landers and rovers with spacecraft capabilities that support the pursuit of these science questions. Such investment will reduce the risk of technologies and capabilities, enabling viable Mars surface missions to compete in the Discovery Program. Such missions will also utilize continued investment in instrument development and miniaturization to better yield capable instruments with mass and power requirements suitable for accommodation on smaller spacecraft.