High priority science objectives that are best achieved from Mars orbit. D. Rogers[1]*, T. Glotch[1], C. Edwards[2], S. Ruff[3], V. Hamilton[4], B. Ehlmann[5], A. McEwen[6], M. Salvatore[2], B. Horgan[7], J. Wray[8], [1]Stony Brook Univ., [2]Northern Arizona Univ., [3]Arizona State Univ.,[4]Southwest Research Inst., [5]Jet Propulsion Laboratory, California Inst. Technology, [6]Univ. of Arizona, [7]Purdue University, [8]Georgia Inst. Technology *deanne.rogers@stonybrook.edu

Introduction: The MEPAG Goals document includes a number of high priority science objectives that can only be achieved from an orbital/aerial platform, as described in the 2015 NEX-SAG report [1]. Meeting these objectives would require a high-resolution imager, IR (SWIR and/or MIR) spectral imaging, thermal imaging, an imaging radar, atmospheric sounding instruments, and a wide-angle weather camera [1]. Some of these instruments cannot be accommodated by present small satellite capability, and use as a suite requires a capable orbiter. Here we reiterate the importance of the NEX-SAG mission concept, because it would: (a) address multiple high-priority MEPAG science objectives, (b) provide important measurements for understanding terrestrial planet evolution and habitability [2], and (c) provide critical information to enhance landed science and planning for human exploration. Mars Sample Return (MSR) remains the highest priority for the Mars community. But, these other high priority objectives should not be eclipsed by MSR within the Mars programming in the coming decade, particularly if a future Mars exploration strategy includes additional rovers and/or human exploration.

High-level science objectives (broadly grouped) and required measurements:

1. Mapping shallow volatile reservoirs to (a) quantify the H_2O and CO_2 inventories, (b) characterize surface/atmosphere exchange, (c) understand recent climate change, and (d) enable accurate assessment of H_2O accessibility/depth for ISRU and human exploration. These science objectives are detailed under MEPAG Goals 1, 2, 4, and require an imaging radar plus thermal IR instrument to characterize regolith overburden.

2. Mapping rock and mineral compositions and abundance to (a) characterize environmental transitions recorded in the stratigraphic record and (b) quantify the bulk H_2O content in preparation for human exploration. These science objectives are described in detail under MEPAG Goals 3 and 4, and would require both high-resolution IR spectral and visible imaging to relate compositional information to stratigraphy.

3. Characterizing dynamic processes with applications to atmospheric processes and identifying possible regions of liquid water/brine flow (recurring slope lineae, or RSL) maps to MEPAG Goals 1, 2, 4. This requires high resolution imaging to monitor RSL and other sites of surface change, and IR imaging spectroscopy to characterize hydration and compositional changes to assess possible modern habitats for life. Measuring winds and characterizing transport and other dynamic processes will help to understand current and past climates and to support entry, descent, and landing.

Benefits from simultaneous flight of all/most instruments: Though each of these measurements could be carried out individually on separate platforms, the impact of the combined measurements would provide insight that is greater than the sum of its parts, in large part because volatiles are time-varying. For example, thermal IR measurements would provide critical thermophysical characterization of the overburden, necessary for accurate retrieval of ice abundance and depth as radar is less sensitive to the upper cm's. For RSL, IR imaging spectroscopy combined with high resolution visible imaging is needed to assess the darkening mechanisms at RSL (wet/dry; salts present/absent) and track changes in near surface water vapor; imaging radar could be used to search for and track changes in adjacent ground ice / subsurface brines [1].

Integration with other Mars Exploration strategies: Lander/rover missions would benefit greatly from detailed contextual information, correlative stratigraphy, and atmospheric data from orbit. For example, detailed petrographic information or radiometric age dates from rovers/samples could be more widely applicable if linked to coeval units mapped from orbit [2]. Currently available data (or those that operating missions might yet acquire) are generally not adequate for the detailed context needed in this regard. In addition, planning for human exploration requires quantification of volatile reservoirs and hydrated mineral species at the scale of meters, especially for assessment of potential Special Regions [3].

Cross-cutting science and opportunities for discovery: The payload described above would also enable (a) increased data coverage of exposed rock stratigraphy and/or landforms for which presently, no high-spatial resolution compositional data (<18 m/pixel) exist, and (b) a new view of the Mars' shallow subsurface with the capability to map/discover buried landforms (e.g. deltas, fluvial units).

Information needed to mature this concept: The technology is mature enough for development to be incorporated on an orbiter in the near future [1]. The concept would benefit from a detailed analysis of science impacts/trades for implementation as a single orbiter for contemporaneous measurements envisioned by NEX-SAG vs. a smaller instrument suite or multiple orbiter implementation. Assessment of whether current data return capabilities are adequate to achieve the spatial coverage needed to meet the science objectives is also needed.

References: **[1]** MEPAG NEX-SAG Report (2015), Report from the Next Orbiter Science Analysis Group (NEX-SAG), http://mepag.nasa.gov/reports.cfm. [2] Ehlmann, B. L., et al. (2016), JGR. Planets, 121, 1927–1961. [3] Rummel, J. et al. (2016), Astrobiology 16, 119-125.