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Summary: Mars Next Decade planning provides a decadal, watershed opportunity to refocus mission objectives beyond (1) just repeating or refining prior measurements or (2) pursuing a singular (sample return) Pathway. Tomorrow's broader context includes human and robotic exploration of Mars, implemented by a multi-decade partnership among SMD, HEOMD, and OCT. The opportunity cost of defaulting into the past decade's Pathway convergence is high.

Introduction: Many investigations and concepts for Mars-exploration next steps propose to:

1. Continue to fly instrumentation similar to prior successful missions, with goals like increased areal coverage (e.g., covering more of the planet with HiRISE resolution), increased resolution (e.g., down to individual lander-killing rocks), or change detection (e.g., periodic reimaging of known or latent gully sites),
2. Develop novel mobility systems in an effort to enable larger surface payloads, or visual or physical access to more challenging terrain like rock fields, dunes, scarps, and gullies, or
3. Provide stepping stones to a more elegant and affordable MSR (sample return) architecture, including demonstration missions for coring, caching, and ascent to Mars orbit.

This abstract suggests that an alternative perspective may be more likely than these approaches to yield significant, visible progress understanding Mars as a terrestrial planet, possible abode of life, and destination for human exploration.

MSR Need Not Be the Only Pathway Option: Recent planning, and consequent NRC decadal guidance, have put MSR in the critical path for all future Mars exploration; the current House markup language reinforces MSR's primacy. Little else is under study for Mars on the way toward human exploration of the planet. However, much about Mars remains fundamentally unknown irrespective of the tremendous knowledge to be gained from providing contextual samples to terrestrial analysis. Furthermore, significant advances are required to fill strategic knowledge gaps for human exploration missions and systems, again largely orthogonal to MSR as envisioned by the SMD science community [1]. Today's broader planning context, based on long-term partnership among SMD, HEOMD, and OCT that must be mutually beneficial, implies that MSR should be but one of a set of precursor investigations that begins where the Mars Exploration Program has brought us so far, but leads toward a potential era of human exploration.

Alternative Investigations: Knowledge about Mars has increased dramatically, especially via recent orbiting assets (Odyssey and MRO). In addition, implementation of three distinct landing-system architectures has provided heritage for multiple, reliable methods of reaching the surface. And three generations of mobility systems have demonstrated increasingly capable, long-lived, long-range access. Taken together these contemporary capabilities mean:

1. We know how and where to land
2. We understand significant swaths of Mars terrain at sub-0.5-m scale, and can "order up" such scrutiny for specific locations
3. We understand how to traverse complex terrain, can use orbital imagery for path planning, and use autonomy for hazard avoidance
4. We know how to provide and operate a reliable telecom relay network in Mars orbit.

Reworking these very issues would not be the most effective use of prior investment; instead, this foundation could be the basis of a Mars Next Decade strategy. For example, orbiter science could be focused on gaps in type of knowledge rather than greater resolution; technologies for robust mobility under unprecedented or extreme conditions could be kept off the critical path of flying reliable missions.

Example Alternate Mission #1: Repeat-pass inteferometric SAR (synthetic aperture radar) could yield completely novel information about Mars of keen and widespread interest to both the science and human space flight communities: ◆ subsurface features (caves, lava tubes, underground channels, buried gullies); ◆ surface variability (at scales of a few mm/yr) including Aeolian and hydrological features; ◆ mapping of polar cap seasonal variability; ◆ local morphology and altitude (at scales well below MOLA and coverage far greater than HiRISE stereo).

Example Alternate Mission #2: Surface systems could be based on *less* robust mobility than we fly today (or the same, but without the need for additional engineering complexity associated with incremental mobility improvements such as rovers that look like crabs). Missions could rely *less* on complex navigation (given high-resolution path planning done from orbit). Landing task-focused science instrumentation precisely, and using orbital imagery to guide roving, could enable even MSR more expeditiously than conventionally proposed [2]. A modest landing system to a site already characterized by HiRISE and CRISM, and without a large stereo camera mast for onboard navigation, is an approach worth exploring. Maximizing proven implementation solutions for mobility and navigation would allow focusing SMD's and OCT's limited development resources on approaches for sample collection, sample preservation (including volatiles and atmospheric samples), and planetary protection.

More Forward-Looking Pathway Options: The Mars Next Decade replanning window provides an opportunity to frame bold future missions that go beyond reflying (or incrementally enhancing) instrumentation suites at or en route to Mars today. The current generation of such instruments is already providing invaluable information, but with that information in hand, Pathways can be defined that look beyond MSR while expediting it as well.

In such a Pathway, MSR would not be represented as the culminating SMD mission but rather as an essential step toward retiring specific risks and identifying the most promising exploration sites for humans – a role also served by other, complementary types of missions and instruments. For example, lava tubes found via SAR would not just be interesting to volcanologists but also to efforts to characterize possible sites for long-term human presence due to the availability of natural radiation shielding.

Summary: Using Mars Next Decade to build a new continuum of Mars exploration, that transitions from an SMD-only program to a future-oriented NASA-wide partnership, we could escape the conceptual trap of fashioning a future too much like the present, of that seeks to improve upon proven implementation approaches where unneeded for new science leaps. Most technologies needed for MSR exist already; what is lacking is engineering development and flight qualification. MSR could be accomplished more quickly than conventionally envisioned by a community accustomed to each mission being more complex than its precedessor.

Alternate mission types, deploying modern sensors not yet used at Mars, could enter unprecedented domains of knowledge we cannot access merely by increasing precision of measuremens already made. Considering novel measurement campaigns more broadly could open multiple viable Pathways to the kind of information we need to determine Mars' past and present habitability, and thus prepare for joint robotic and human exploration.

References: [1] B. Sherwood, Enabling Human-Compatible Planetary Protection: A Mars-Next-Decade Pathway Option, this conference. [2] B. Ehlmann et al., MER Caching Rover for 2018 Exploration of Ancient Mars, this conference.