**International Mars Ice Mapper Mission: Concept Mars Mission to characterize the subsurface water ice for resource utilization and the future human Mars exploration.** R. Davis[1], M. Amoroso[2], M.A. Viotti[3], E. Ammanito[2], R. Mugnuolo[2], T. Haltigin[4], E.Boulais[4], P. Plourde[4], S. Lafrance[4], D.M.H. Baker[6], T. Usui[5], M.S. Kelley[1], R. Saylor[6], B. Collom[1]. [1]NASA Headquarters (richard.m.davis@nasa.gov; michael.s.kelley@nasa.gov; robert.b.collom@nasa.gov), [2]Agenzia Spaziale Italiana (marilena.amoroso@asi.it; eleonora.ammanito@asi.it; raffaele.mugnuolo@asi.it), [3]Jet Propulsion Laboratory, California Institute of Technology (michelle.a.viotti@jpl.nasa.gov), [4]Canadian Space Agency (timothy.haltigin@asc-csa.gc.ca; etienne.boulais@asc-csa.gc.ca; sebastien.lafrance@asc-csa.gc.ca; patrick.plourde@asc-csa.gc.ca), [5]Japan Aerospace Exploration Agency (usui.tomohiro@jaxa.jp), [6]NASA Goddard Space Flight Center, (david.m.hollibaughbaker@nasa.gov)

**Introduction:** Since 2019, the International Mars Ice Mapper (I-MIM) mission concept has been developed jointly by partner Agencies [Agenzia Spatiale Italiana (ASI), the Canadian Space Agency (CSA), the Japan Aerospace Exploration Agency (JAXA), and National Aeronautics and Space Administration (NASA)]. The mission's driving Reconnaissance Objectives (ROs) are to identify ice deposits within the uppermost 10 m of the martian subsurface, to characterize the physical properties of its overburden, and to characterize candidate, ice-accessible sites for future human-robotic exploration and eventual in-situ resource utilization. Here, we provide an update on the mission's second phase of concept formulation, including a revised mission architecture and cross-cutting science and reconnaissance objectives.

**Measurement Definition Team:** In 2021, the partner agencies tasked a competitively-selected Measurement Definition Team (MDT) to: (1) define the core measurements for the anchor payload—a 930 MHz Synthetic Aperture Radar (SAR) Imager/Sounder—required to achieve the ROs; (2) suggest augmentations in the form of science investigations and hardware that may be included, and; (3) develop a model concept of operations based on the findings of Tasks 1 and 2.

The MDT concluded in its August 2022 Final Report [1], that the baseline mission, consisting of a single instrument (a SAR/sounder centered at 930 MHz), would largely satisfy all of the ROs and would provide ample opportunity to conduct high-priority science investigations.

In addition, the MDT recommended that the partners consider including payloads that would strongly complement the SAR and advance both fundamental science and science supporting future human exploration. These highest priority MDT-recommended payloads include: a very high frequency (VHF) radar sounder, a high-resolution optical imager, and a sub-millimeter sounder for atmospheric profiling.

**Revised Mission Concept Architecture:** Based on the recommendations from the MDT, the I-MIM team developed an updated mission architecture with three spacecraft hosting complementary payloads to advance cross-cutting human exploration objectives and achieve high-priority science at modest cost to each partner (**Fig. 1**):

*Element 1 – Ice-Mapping Orbiter:* A JAXA-provided bus would host two radar instruments: a CSA-provided polarimetric L-band (930 MHz) Synthetic Aperture Radar (SAR) as well as an ASI-

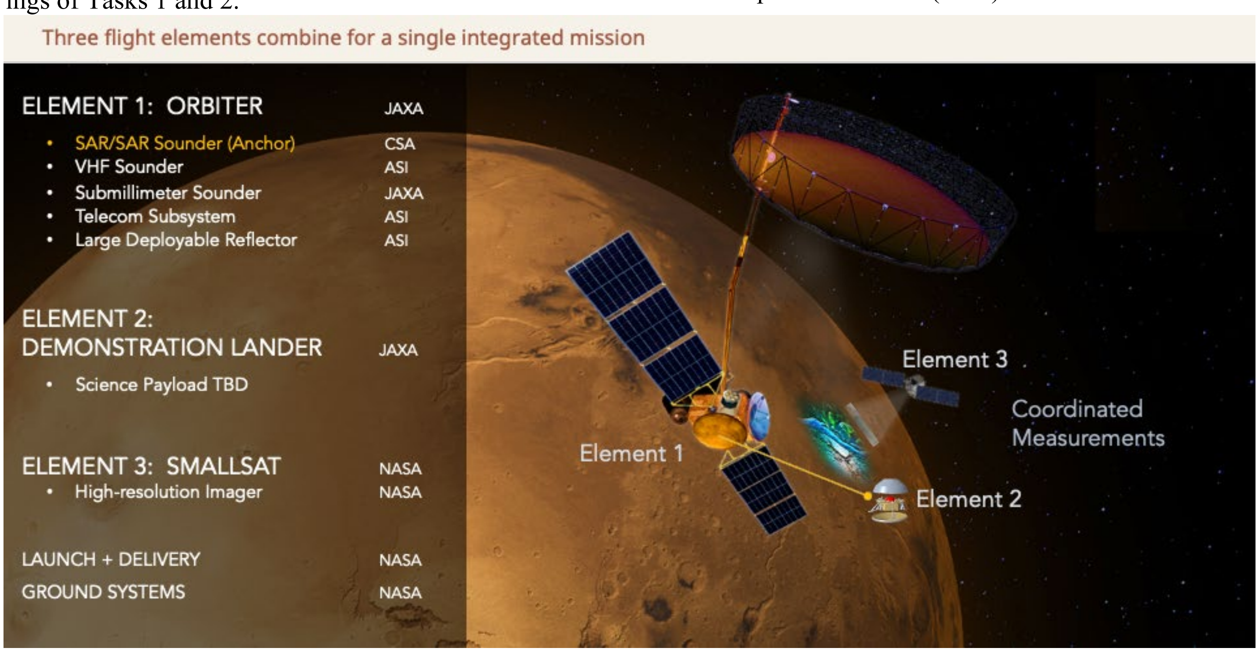


***Figure 1.*** *The mission partners are considering an I-MIM mission architecture consisting of three elements to provide coordinated measurements that address cross-cutting science and reconnaissance objectives.*

provided Very High Frequency Shallow Radar Sounder (100-250 MHz) and Large Deployable Reflector to act as part of the telecommunications subsystem. JAXA would also provide a submillimeter sounder for atmospheric sensing. This orbiter would address reconnaissance and science priorities, replenish communications relay infrastructure (high data volume and legacy), and expand climatology and space-weather studies.

*Element 2 – Demonstration Lander:* A JAXA-provided demonstration lander would piggyback on the the main orbiter to provide ground-truthing capabilities with a potential complementary small instrument package.

*Element 3 – Free-flying Smallsat with High-Resolution Imager:* A NASA-provided, free-flying smallsat with a high-res imager would provide high-resolution imaging for context and continuity under a small low-cost mission profile and to meet the requirements for multiple scientific investigations and future mission site selection.

In addition, NASA would be providing launch and delivery and mission ground systems.

**Revised Statement of Objectives:** With this second phase of mission concept development, the mission partners are drafting a revised set of objectives that focus on cross-cutting target investigations addressing both science and reconnaissance needs:

1) *Water Ice*: Identify the presence or absence of near-surface water ice, measurer its depth and abundance, and map its distribution.

2) *Overburden*: Constrain the structure, stratigraphy, roughness, and compactness of near-surface lithic material.

3) *Candidate Sites*: Assess the scientific and engineering suitability of candidate sites for future robotic and human exploration requiring access to near-surface water ice.

4) *Planetary Evolution*: Investigate Mars' past and present environmental processes and implications for habitability through its geological and atmospheric record.

5) *Volatiles*: Characterize the role of atmospheric structure and dynamics in the exchange of volatiles amongst the martian subsurface, surface, and atmosphere.

These revised objectives and mission architecture respond to the I-MIM MDT report and recommendations of the Planetary Science and Astrobiology Decadal Survey 2023–2032 [2]: "The development of the goals and measurement requirements for missions addressing both science and human exploration interests should be developed to meet the objectives of both communities," (p. 22-12) and; "NASA should consider an ice-mapping mission that prepares for [In Situ Resource Utilization] by humans and addresses the priority climate science questions at Mars related to near-surface ice." (p. 22-12)

**I-MIM to Enable Future Mars Exploration:** An expanded portfolio of lower-cost and partnered missions is a key feature of plans in development for the future of Mars exploration in conjunction with Mars Sample Return [e.g., 3]. The I-MIM mission concept fits within this future exploration strategy, leveraging international partnerships and possible commercial contributions. Critically, I-MIM would help to address the issue of an aging orbital infrastructure at Mars to enable the next generation of decadal-level scientific investigations of the planet. Further, I-MIM would address numerous cross-cutting themes and objectives within NASA's Moon-to-Mars architecture [4] and partner strategies, helping pave the way for the future of human exploration.

**References:**

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