High-Resolution Imager Replacement (HIREP) Measurement Definition Team (MDT)

Terms of Reference

August 6, 2026

Purpose

The High-Resolution Imaging Science Experiment (HiRISE) on board the Mars Reconnaissance Orbiter has been in operation since 2006, returning over 30 Tb of high-resolution imaging data at resolutions as high as 30 cm/px in three colors (blue-green between 400-600 nm, red between 550-850 nm, and near infrared between 800-1000 nm). Over its 20 years of operation, it has returned more than 100,000 images, yet it has generated coverage of only around 5% of the total surface of Mars. As the camera has aged, incremental degradation of its capabilities has been observed and, as of August 2026, the camera has limited ability to return images at the highest resolution, and with full color across its imaging strip. Furthermore, the Mars Reconnaissance Orbiter (MRO) spacecraft itself has a limited lifetime and, while generally healthy, is of an age where planning for renewal of its initial capabilities is prudent. Despite its present limitations, HiRISE remains the highest resolution imaging asset in orbit around Mars and remains a critical asset for use in scientific investigation and future mission planning, including for both robotic landers and potential future human-led missions.

Recognizing the continued need for high-resolution[1] surface imaging well into the future, as well as the increasing fragility of the existing HiRISE camera, the Mars Exploration Program is anticipating replacing or supplementing HiRISE with imaging capabilities that can be used for both scientific investigation as well as in support of future Mars exploration by unmanned and manned missions. To prepare for future human exploration of Mars within the Moon to Mars architecture requires sufficient precursor data (prior to the first human landing) to assess and certify potential landing sites. Similar data must be acquired to support future landed robotic missions. A replacement high-resolution capability, therefore, needs to be able to provide information necessary to make these assessments at one or more potential landing sites at a level commensurate with, or better than, HiRISE[2].

The acquisition of further high-resolution imagery also holds the promise of returning breathtaking images of the unexplored Martian surface and providing groundbreaking new

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[1] Defining a suitable definition of 'high-resolution' in this context will be part of the task of the MDT.

[2] Note that 'better than' does not necessarily mean improvement upon any specific characteristic (e.g., resolution, SNR, etc.) but, rather, an enhanced ability to address the needs of the landing site assessment process.

data that can refine our understanding of Mars' climate and geology and better characterize what we know about the planet's habitability. Such a replacement imaging system should therefore be designed to observe the planet with scientific discovery in mind and hence should potentially carry new capabilities and characteristics to expand upon what has already been observed at Mars with HiRISE and/or other assets.

Statement of Task

The High-Resolution Imager Replacement (HIREP) Measurement Definition Team (MDT) is chartered to perform the following tasks, with the express intent of supporting NASA Mars Exploration Program (MEP) in the formulation of requirements for an imaging payload to replenish or supplement HiRISE and accomplish tasks deemed necessary as precursors for future robotic and human exploration of Mars:

Task 1: Establish priority measurements for both research science and landing site selection goals

- Imaging data can serve dual roles and are necessary for advancing our knowledge about the Martian surface environment as well as for characterizing the surface properties of notional future landing sites.
- Specifically, for landing site selection, the NASEM report *A Science Strategy for the Human Exploration of Mars* indicates the need for topographic information to plan human campaigns, as well as the need for "information on rock abundances, thermal inertia, slopes, surface and subsurface ice abundance, and likely other requirements that may manifest in the future". The MDT should assess the desired imaging capabilities of the next high-resolution imaging system and what observational modes would best serve the landing site selection process.
- For science, the science objectives[3] of the HiRISE camera can serve as a starting point for the next high-resolution imager; however, to the extent that future landing sites will likely occur in mid-latitude regions with near-surface water ice resources, and that these regions may be prioritized for future observation, the MDT should assess whether overall investigation priorities might change from those of HiRISE, which had a more global observational mandate. Are there new investigations that can be enhanced, for example, with a more zonally focused region of observation?

Task 2: Identify desired capabilities necessary to make these priority measurements as well as ensure their utility for human-rated landing site certification

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[3] Scientific objectives of the HiRISE payload may be found in McEwen et al. (2007), at https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2005JE002605

- The capabilities and needs of HiRISE, as used to support landing site certification for the Phoenix, MSL, InSight, and Mars 2020 missions may be baselined for future high-resolution imaging. Given the different nature of human landing activities (landed mass, potential plume-surface interaction (PSI) of more powerful retrorockets, and greater scientific capacity, among others), enhanced imaging capabilities and/or needs beyond those of HiRISE may be necessary or desired. This could include, but is not limited to, spatial and/or temporal resolution, spacecraft pointing accuracy, wavelength coverage, and signal-to-noise ratio. The MDT shall identify these potential enhanced capabilities and needs.
- Identify the requirements of the carrier spacecraft necessary to obtain the desired priority measurements. These should include, but not necessarily be limited to, spacecraft size, instrument accommodation (both the imager and any complementary instrumentation—see Task 3 below), pointing and spacecraft stability, and telecom capacity (e.g., DTE, cross-link).
- The on-board data processing capability of the carrier spacecraft should also be assessed compared to MRO. Data that are acquired, but unable to be returned, provide no benefit to the program or the science community. Are there improved means of software compression that would enable greater data return? Are there next-generation communication protocols that would substantially increase bandwidth? Are there artificial intelligence (AI) approaches that would facilitate acquisition and/or return of the most valuable data? Would such software require more powerful on-board computational resources, and are these resources presently available and sufficiently mature to be beneficial? If not, what investments would be necessary in computing and telecommunication technologies that could be implemented in the short term (1-3 years) for incorporation in a future launch window. The MDT shall seek to identify anticipated data processing needs to support adequate imaging coverage of a notional human landing/exploration zone of order 100 km radius, including multiple-pass coverage for DTM generation and diurnal/seasonal imaging variability.

Task 3: Identify any complementary instrumentation that would substantively enhance the primary return of the imager

- Is there complementary instrumentation that would enhance the return of the high-resolution imaging payload for purposes of landing site selection? Identify strawman payload elements, their approximate size, weight, power, and data volume, and description of the ways in which these additional payload elements would augment the returned data value. To the extent possible, identify engineering impacts of multiple instruments (potential interference, mounting and boresight alignment requirements, etc.) Here, the proper metric for evaluating 'enhancement' should be relative science value (loosely described as 'science per dollar') rather than absolute science return. Preference should be given to small and/or lower cost elements.

Task 4: Identify the preferred orbit(s) for the imaging system to maximize its return for both science and exploration. For those measurements deemed of higher priority that cannot be accomplished in the preferred orbit(s), identify what alternate orbit(s) would allow obtaining those measurements.

- To first order, lower altitude orbits provide better spatial resolution, but at the expense of spatial coverage. It is not clear, a priori, that an orbit similar to that of HiRISE (circular, ~300 km) is ideal for the next high-resolution imager. The MDT shall be tasked with assessing the offsetting factors that could maximize science return and achieve the needed measurements for landing site selection for missions beyond the 2031 timeframe. For example, a lower orbit may limit the total coverage achievable by the imager of priority landing sites in the near term but may afford exquisite spatial resolution that provides novel data to the science community. Conversely, a higher orbit may provide acceptable spatial resolution for landing site evaluation, and more spatial coverage, but such an orbit might limit other add-on capabilities of the imaging payload (see Task 2). Smaller imaging payloads on a network of orbiters may provide time of day coverage that is deemed by the MDT to be a more important capability than HiRISE-level resolution.

Assumptions and Guidelines

It shall be assumed that a 2031 launch date is being targeted for the next high-resolution imaging payload, although subsequent launch windows may also be possible. As such, the technology needed to achieve the desired capabilities should be assumed to be presently available; it should be noted, though, what future technologies might be in development at or near TRL 6 that could be implemented in the short term (1-3 years) for incorporation in a future launch window.

Although Task 3 affords the opportunity to describe complementary payloads to augment the return from the primary imaging payload, these elements should not be essential to achieve the needs of the mission. Future launches may provide additional opportunities for data collection that will augment the imaging, from separate platforms.

Several recent studies and reports have been produced that are pertinent to the work of the MDT, and which may be instructive. These include:

- Mars Exploration Program Future Plan

- Moon to Mars Architecture Definition Document
- NASEM Report: A Science Strategy for the Human Exploration of Mars
- Outbriefs from Mars Exploration Program Commercial Services Studies[4]
- The International Mars Ice Mapper (I-MIM) MDT Report + Addendum

Methods

- The HIREP MDT will consist of 2 Chairs and ~10-15 members selected from all interested communities. These should include, but are not limited to, members of the Mars science and Mars exploration communities. A range of discipline expertise is desired, including in areas to do with landing site safety, instrument design, and data handling. Participation in prior Mars Landing Site workshops may provide a valuable perspective on how high-resolution imaging data are used for spacecraft exploration.
- A selection board will be convened, made up of members of MEP, MEPO, and unconflicted outside subject matter experts. Participants in the selection board will not be eligible to participate in the MDT.
- It is anticipated that much of the MDT's work will be carried out using email and teleconferencing, with one face-to-face meeting as schedule allows. To the greatest extent possible, depending on geographical distribution of the MDT, teleconferences will be scheduled during working hours.
- Member selection:
    - An open call for self-nominations to the HIREP MDT will be announced
    - Applicants will be asked to provide their CV or resume of no more than two pages, along with answers to one or more open-ended questions.
    - Non-US applicants are both welcome and encouraged to apply; however, participation will be subject to a no-exchange-of-funds policy (including travel).

Schedule

It is expected that the HIREP MDT will begin its work as soon as possible after selection and shall present deliverables to the MEP as per the following proposed target schedule. Specific dates will be refined as the MDT progresses

- September 2026 — Kickoff meeting of the MDT
- November 2026 — Interim results presented to MEP
- 1st Quarter 2027 — Face-to-Face MDT meeting (location/date TBD)

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[4] Publicly releasable information will be provided to the MDT by the Mars Exploration Program Office

- January 2027 Summary presentation of findings/recommendations
- February 2027 Delivery of final report to MEP

Deliverables

The primary deliverable of the MDT will be a written report with the team's findings and recommendations for capabilities of a next-generation imager. The report shall contain a measurement traceability matrix (MTM) that flows from objectives (e.g., science, landing site selection/certification) to investigations and to the actual measurements and required capabilities of the instrument(s). As no specific architecture is specified, the MDT may choose to develop MTMs for multiple different scenarios (orbits, payloads, etc.) so long as each scenario addresses the dual objectives of science and landing site selection. The report shall be delivered to both the Mars Exploration Program and the MEP Program Office. Additionally, a summary presentation, delivered in PowerPoint format (as indicated above), shall be provided to the same recipients. The HIREP MDT chairs may be called upon to present team findings at one or more public community meetings (e.g., MEPAG).