Mars NanoOrbiter:
A CubeSat for Mars System Science

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Key Mission Characteristics: First color images of the far-sides of Phobos and Deimos and their global mapping at 6m/pixel | Continuous (1-2 hr.), high temporal resolution imaging of cloud, frost, and dust storm phenomena on Mars | International science team, including ties to JAXA's 2024 MMX mission | Caltech PI with commercial and international partner subsystem builds and JPL system engineering | Low-cost, high-heritage, direct descendent of the 2018 MarCO 6U cubesats that launch with InSight | Full proposal submitted to NASA, Nov. 2017 | Can be ready for launch with Mars-2020 | Compatible with all Mars-direct planetary mission trajectories

Science Goals and Objectives

MNO science supports Decadal Survey Objectives, the scientific goals of the MEPAG and SBAG programs, and supplies crucial information and technology demonstrations needed for further Mars system exploration

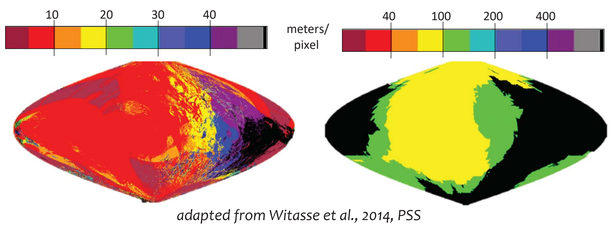
Goal 1. What are the origin, evolution, and properties of Mars' Moons?

A. Map completely the far-sides of Phobos and Deimos at high spatial resolution (≤30 m/pixel req; <6m/pixel expected) and study landforms that provide insight into the internal composition and geologic history of both moons

B. Determine definitively the density of Deimos to understand its composition, internal structure, and similarity to Phobos

C. Map the properties of Phobos and Deimos surfaces to search for atypical phases, Mars-like compositions, changes since prior imaging, and variation in properties relevant to future exploration -- enabling for JAXA's MMX

MNO would provide 6m/pixel stereo 4-band color global maps of the Mars moons for shape models, density determination, mapping composition and physical properties, and aiding MMX landing/sampling system decisions



adapted from Witasse et al., 2014, PSS

Goal 2. What drives Mars' dynamic weather?

A. Monitor the evolution of clouds, largely unexplored by the suitably instrumented, solar-locked missions that have flown to date, **and the initiation and growth of dust storms at high temporal resolution** to understand why some storms are regional and others become global events

B. Monitor dynamic Mars volatiles (frosts and fogs) with high temporal resolution, revealing new insights into phenomena like the Valles Marineris water fogs, water ice defrosting of the mid-latitudes, and the transport of ice aerosols

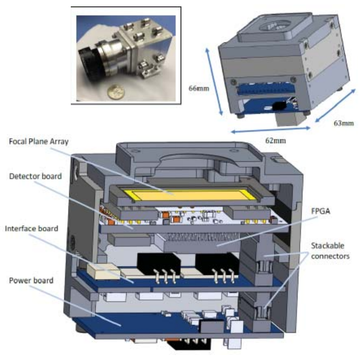
Technology Objectives

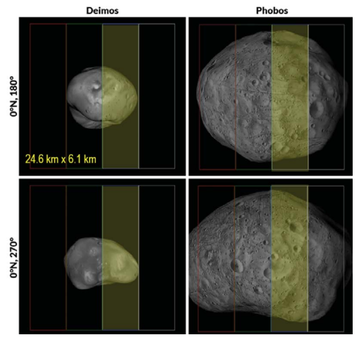
MNO would serve as a trailblazer for future small satellite missions by

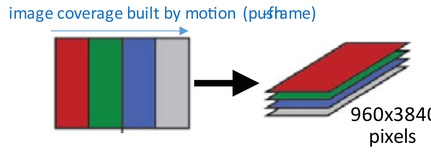
- Demonstration of Mars orbit insertion by a CubeSat
- Demonstration of repeated small body flybys
- CubeSat autonavigation software demonstration

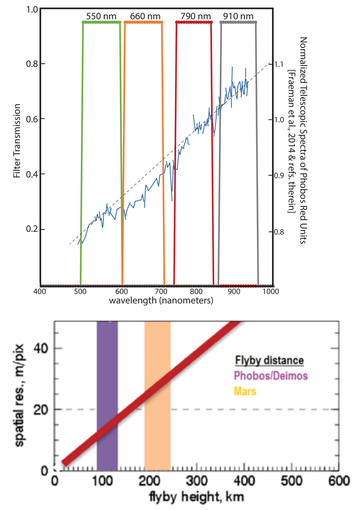
Science Payload

- **Visible/Near-Infrared Push-Frame Multispectral Imager**
  - 0.5 mrad IFOV, f/2.8
  - 4-VNIR channels
  - EECAM detector, Caltech optics
  - M2020, OCO-3, NEAScout heritage
- A possible second science instrument thermal imager, surface reflector/impactor, or He^+ imager for the payload is currently being evaluated; Phase A/B trade depending on propulsion tank final size



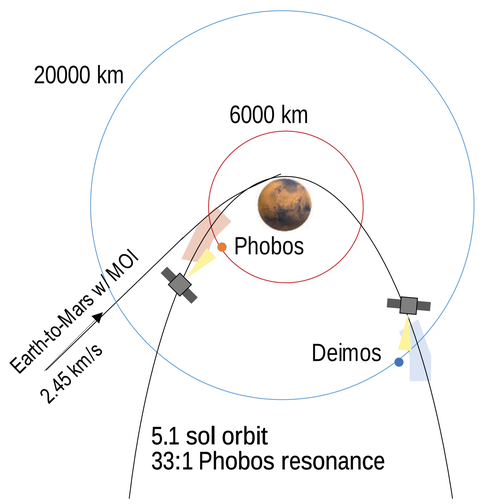




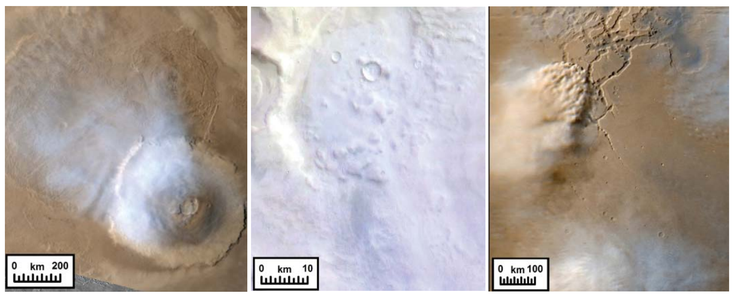


Key Mission Characteristics

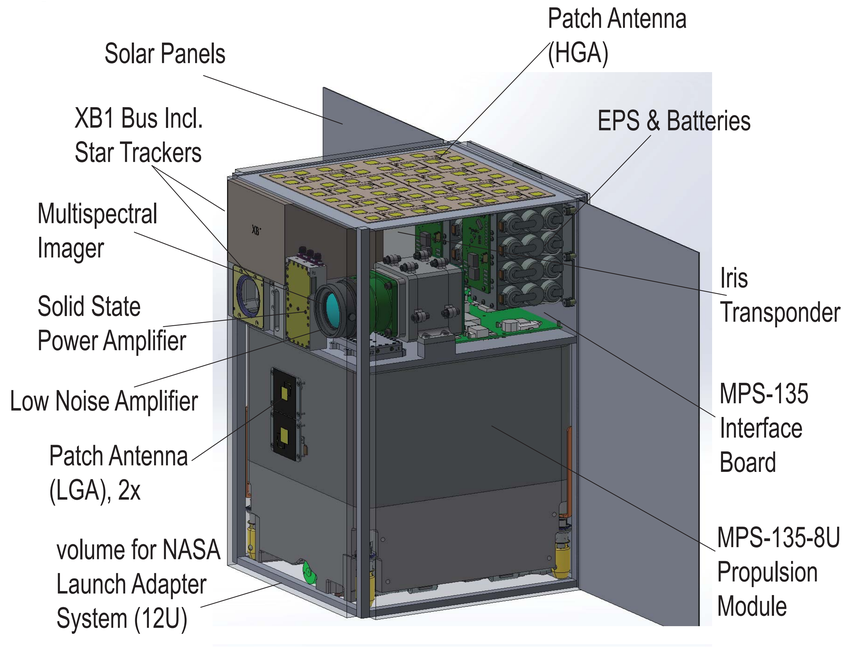
- Launch as early as 2020 on Mars-2020
- Navigate to Mars and independent insertion into an elliptical, equatorial Mars orbit
- Multiple close (50 km) flybys of Phobos and Deimos for global coverage at multiple phase angles
- Orbit enables high temporal resolution Mars observation at varying locations and times of day with 275-km perigee, 115,000 km apogee



MNO would monitor clouds, dust storms, water fogs, and timing and rates of frosting/defrosting



Implementation



- 2 Spacecraft, 12U each
- 24 x 24 x 36 cm each
- Deploys with 12U canister
- 25 kg w/ 12% Margin
- 40 W @ Mars
- 1.5-2 U for science payload
- AeroJet propulsion system with ΔV 1100m/s enables Mars orbit insertion, moon flybys
- Blue Canyon XB1 avionics
- SDL/USU IRIS radio (licensed from JPL) Electra protocol-enabled w/ 0.06-64 kbps data rate, >800 science images for the primary mission (>10 GB/spacraft)

Mission Schedule

- 2-year spacecraft build with 25% schedule reserve
- Prime mission duration of 1 Earth-year (5 mo. at Mars)
- Anticipated extended mission opportunity for enhanced science return