LUNAR TRAILBLAZER: A PIONEERING SMALLSAT FOR LUNAR WATER, LUNAR GEOLOGY, AND LANDING SITE RECONNAISSANCE. B.L. Ehlmann[1], R.L. Klima[2], D. Blaney[3], N. Bowles[4], J. Dickson[1], K.L. Donaldson Hanna[5], C.S. Edwards[6], R.O. Green[3], M.A. House[7], J. Miura[1], C.M. Pieters[9], D.R. Thompson[3], and the Lunar Trailblazer team [1]Div. Geol. & Planetary Sciences, Caltech, [2]JHU Applied Physics Lab, [3]Jet Propulsion Laboratory, Caltech [4]U Oxford, [5]U Central Florida [6]Northern Arizona U, [7]Pasadena City College, Pasadena, CA, [9]Brown U

Lunar Trailblazer, NASA's smallsat mission for understanding the Moon's water and water cycle [1] is in final stages of test and operational readiness training (Fig. 1, Fig. 2) and expected to launch as a ride-share with Intuitive Machines' IM-2 mission in 2024. Trailblazer's science goal is to understand the form, abundance, and distribution of water on the Moon and the lunar water cycle. In achieving this goal, Lunar Trailblazer also collects key data for reconnaissance of potential future landing sites for human and robotic exploration in the CLPS and Artemis programs.

Trailblazer is optimized to make targeted measurements of infrared properties of the lunar surface to (1) detect and map water to determine its form (OH, H_2O, ice), abundance, and distribution as a function of latitude, soil maturity, and lithology; (2) assess time-variation in lunar water on sunlit surfaces; (3) map the form, abundance, and distribution of water ice in permanently shadowed regions (PSRs); and (4) measure surface temperature to quantify local gradients and search for small cold traps. At the same time, Trailblazer's dataset will provide the Moon's highest spatial and spectral resolution shortwave infrared and thermal-infrared maps to determine volatile distribution and abundance, surface composition for geology, surface thermophysical properties, and reconnaissance for candidate landing sites (Table 1).

Lunar Trailblazer is a PI-led mission at Caltech, managed by JPL with industry partner Lockheed Martin providing the spacecraft and integrated flight system. Operations are led from Caltech, involving students from Caltech and Pasadena City College in operations, and with mission designed and navigation provided by JPL. After post-launch separation from an ESPA ring, cruise to the Moon, powered by a 1 km/s delta-v hydrazine system, takes 4-8 months, depending on the lunar phase at launch. Trailblazer enters a ~100-km polar orbit around the Moon. Targeted data cubes are acquired simultaneously in pushbroom mode with two science instruments: JPL's High-resolution Volatiles and Minerals Moon Mapper (HVM^3) [2,3] and the UKSA-funded, University of Oxford Lunar Thermal Mapper (LTM) [4] (Table 1). Over Trailblazer's ≥1-year primary science mission, each instrument will acquire ≥1000 targeted images of the Moon and additional data for calibration.

Figure 1 Lunar Trailblazer concept and hardware as built.

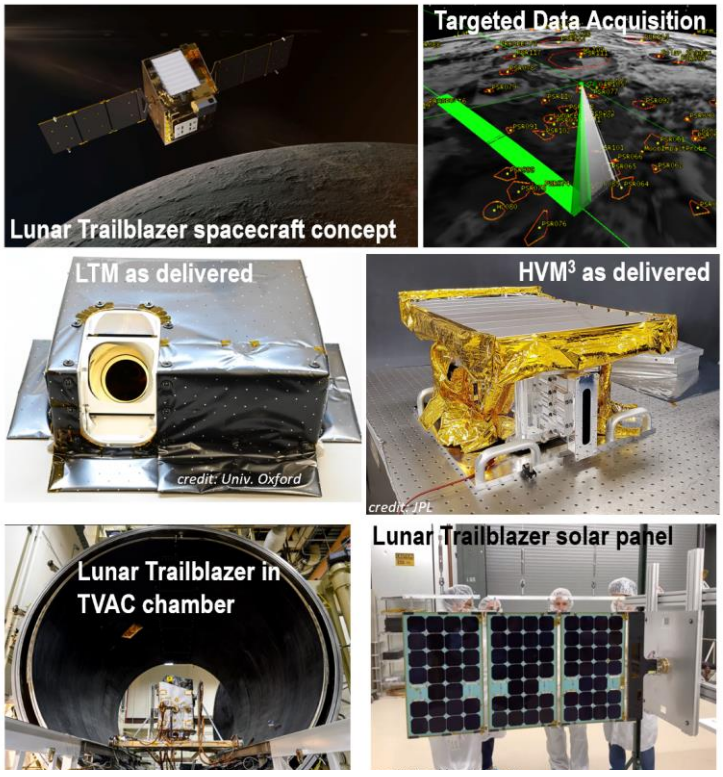
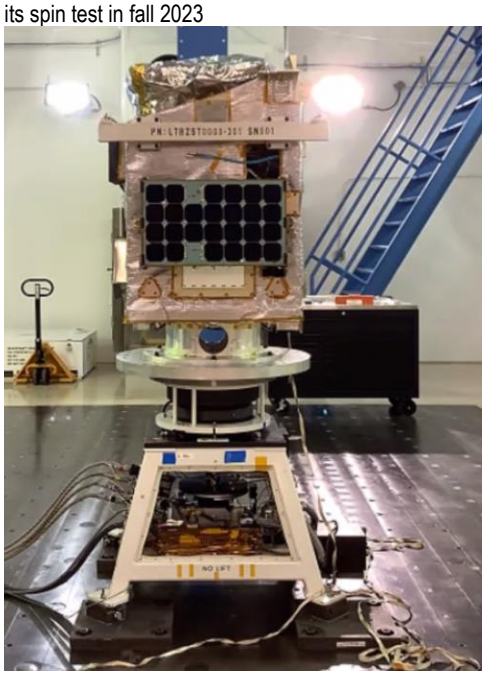


Figure 2. Lunar Trailblazer spacecraft on the table for its spin test in fall 2023



Targets include surfaces within PSRs, sites of distinctive lithologic composition, sites viewed at multiple (≥3) times of day, and targets along latitudinal gradients in areas of homogeneous composition.

Table 1. Current best estimate mission and observing parameters from 100±30 km orbit

Mission Parameters	
Volume, Mass	ESPA Grande, MEV 210 kg
Lifetime	2 years (Launch – End of Primary Science Mission)
Lunar Orbit	100±30km polar
Comm.	DSN compatibility, X-band
HVM[3]	
Spatial Sampl.	50-90 m/pixel
Swath Width	30-55 km
Spectral Range	0.6 – 3.6 μm
Spectral Sampl.	10 nm
SNR	>100 at reference
Uniformity	>90% cross track
# Data Cubes	≥1000
LTM	
Spatial Sampl.	40-70 m/pixel
Spatial Width	14-27 km
Thermal	4 broad bands, 6-100 μm, for 110-400K (±<2 K)
Composition	11 channels, 7-10 μm w/ <0.5 μm resolution
# Data Cubes	≥1000

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References: [1] Ehlmann et al., 2022, Proc. *IEEE Aerospace*, 2022, dor: 10.1109/AERO53065.. 9843663 [2] Thompson et al., 2020, *LPSC 2020*, abs. #2052, [3] Bender et al., 2022, Proc SPIE Imaging Spectrometry, 10.1117/12.2632552 [4] Bowles et al., 2020, *LPSC 2020*, abs. #1380