

LUNAR TRAILBLAZER: A PIONEERING SMALLSAT FOR LUNAR WATER AND LUNAR GEOLOGY.

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Mission Objectives: Lunar Trailblazer is a NASA smallsat mission for understanding the Moon's water and water cycle [1]. Trailblazer is now in the assembly, test, and launch operations (ATLO) phase and is scheduled to launch as a rideshare with the Intuitive Machines IM-2 mission in October 2023 (Figs. 1, 2). The spacecraft will be delivered in spring 2023.

Lunar Trailblazer's goal is to understand distribution of water on the Moon and the lunar water cycle. Trailblazer is optimized to make targeted measurements of the infrared properties of the lunar surface to (1) detect and map water on the lunar surface at key locations to determine its form (OH, H₂O, ice), abundance, and distribution as a function of latitude, soil maturity, and lithology; (2) assess possible time-variation in lunar water on sunlit surfaces; (3) map the form, abundance, and distribution of water ice in the PSRs; and (4) measure surface temperature to quantify local gradients and search for small cold traps.

Mission Profile and Spacecraft: Lunar Trailblazer is among the first generation of rideshare planetary smallsats, selected under the SIMPLEX-2 program. Implemented as a Class-D 7120.5e mission, Lunar Trailblazer is a PI-led mission at Caltech, managed by JPL with industry partner Lockheed Martin Space providing the spacecraft and integrated flight system. Science and mission operations will be led from Caltech. A student collaboration at Caltech and Pasadena City College involves undergraduate students—as well as graduate students and postdocs of the Co-I institutions—in all aspects of mission design and operations.

Lunar Trailblazer has an MEV mass of 210-kg and fits within an ESPA Grande volume (Fig. 1; Table 1). Its hydrazine chemical propulsion system provides ~1000 m/s of delta-v. From its separation from the ESPA ring, cruise to the Moon takes 4-8 mo., depending on the lunar phase at launch. Trailblazer uses its propulsion system to enter into

a ~100-km polar orbit around the Moon and maintains its science orbit via periodic orbital maintenance maneuvers, approximately every 3 months.

Data are acquired simultaneously in pushbroom mode with two science instruments: the High-resolution Volatiles and Minerals Moon Mapper (HVM³) and the Lunar Thermal Mapper (LTM) to determine volatile content, lithology, and surface temperature (Figs. 1, 3; Table 2). The most sensitive measurement uses terrain-

Figure 1. Schematics of Lunar Trailblazer, its launch configuration, fields of view in its pushbroom observing geometry, the HVM³ instrument and LTM instrument

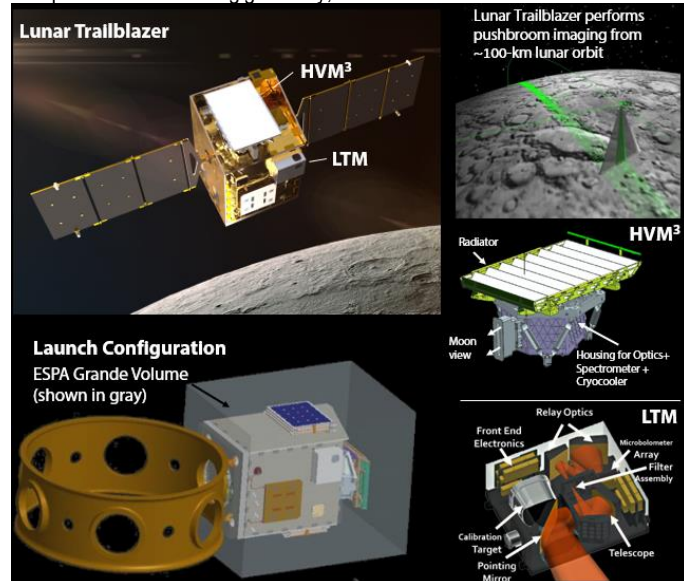
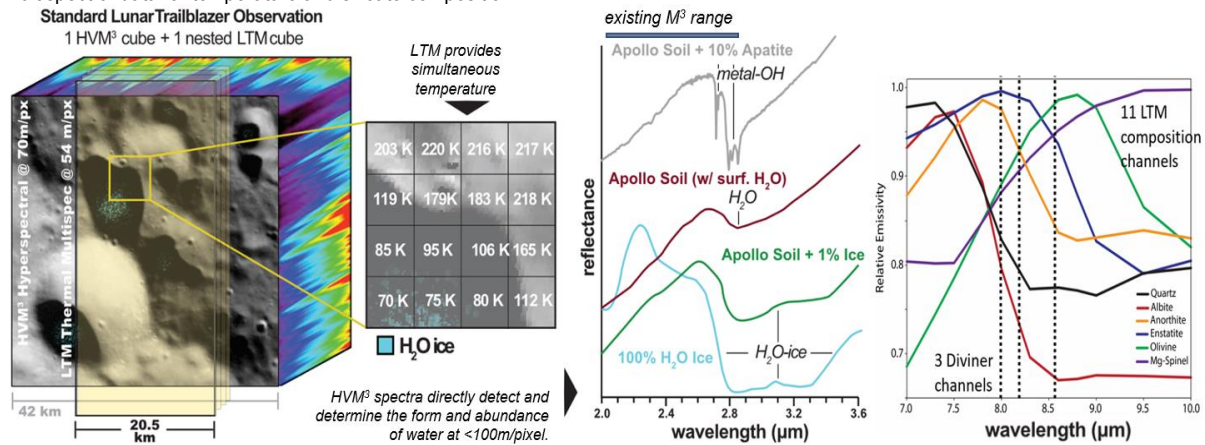


Figure 2. Lunar Trailblazer is in build; select photos from ATLO



Figure 3. Graphic of the simultaneous composition and temperature data that will be acquired by Lunar Trailblazer. The HVM³ imaging spectrometer acquires data in 100's of infrared channels (0.6-3.6 μm) and nested within are simultaneous 14-channel LTM thermal IR multispectral data for temperature and silicate composition.



scattered light to map water ice content in permanently shadowed regions (PSRs). Over Trailblazer's ≥ 1 -year primary science mission, each instrument will acquire ≥ 1000 targeted images of the Moon and additional data for calibration. Targets include sites of distinctive lithologic composition, sites viewed at multiple (≥ 3) times of day, targets along latitudinal gradients in areas of homogeneous composition, and PSRs.

Instruments: HVM³ is a MatISSE-developed, JPL-built, modernized version of the successful M³ imaging spectrometer and has been optimized to identify and quantify water [2]. Active cooling of the focal plane and a spectral range out to 3.6 μm with spectral sampling of 10 nm enable sensitive discrimination of the form and abundance of even small amounts of water by discrimination of the absorption band centers of bound OH/H₂O versus H₂O ice. Longer integration times (5x) enable this capability within PSRs. HVM³ was delivered and installed in December 2022.

LTM is a UK-contributed, University of Oxford-built miniaturized thermal infrared multispectral imager, optimized to simultaneously measure temperature, composition, and thermophysical properties [3]. LTM carries 4 temperature channels for <2 K discrimination of surface temperature and identification of cold traps. LTM additionally has 11

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

Mission Parameters	
Volume, Mass	ESPA Grande, MEV 210 kg
Lifetime	2 years (Launch – End of Primary Science Mission)
Lunar Orbit	100 \pm 30km polar
Comm.	DSN compatibility, X-band
Volume, Mass	ESPA Grande, MEV 210 kg
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

compositional channels to measure the Si-O Christiansen feature, extending prior 3-channel maps at the Moon by the Diviner instrument so as to better discriminate silicate lithologies, particularly silicic and mafic endmembers. LTM delivery is anticipated in February 2023.

Trailblazer's dataset will comprise the Moon's highest spatial and spectral resolution shortwave infrared and mid-infrared maps to determine volatile distribution and abundance, surface composition for geology, and surface thermophysical properties. If mission data return and mission duration permit, after satisfying its science objectives, Lunar Trailblazer will acquire additional data of high priority lunar science and exploration community targets, including geologic investigations of lunar lithologies (e.g., silicic domes, Mg-spinel-rich locations, irregular mare patches, dunite/troctolite regions, pyroclastic deposits) and provide reconnaissance for candidate landing sites. We are accepting suggested targets from the community (<https://forms.gle/AwWsFWLzQPhycXmr7>) [4].

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