# Lunar Trailblazer Mission Description

## Mission Overview

Lunar Trailblazer targets one of the most surprising discoveries of the decade: Water on the Moon. As a NASA SIMPLEx (Small Innovative Missions for Planetary Exploration) program mission selection, Lunar Trailblazer achieves critical advancements for science as a lower-budget, ride-along mission, and is in assembly and test for launch in Q4 2024.

Getting to the Moon

Lunar Trailblazer is different from most planetary missions. Like its sister NASA SIMPLEx missions, Lunar Trailblazer is a “rideshare mission”. Kind of like choosing an Uber/Lyft-pool ride, NASA is taking advantage of the fact that most large missions launch with extra mass capacity on the rocket to bring material to space. To allow more spacecraft “seats” on the ride, launch providers use ESPA rings, a standard add-on with ports to host smaller spacecraft like Lunar Trailblazer.

With its solar panels folded safely for launch, ~200-kg Lunar Trailblazer fits comfortably in ESPA volume. We link via a standard commercial-off-the-shelf part called a “lightband” (a Mark II Motorized lightband, to be exact). Lunar Trailblazer will be finished with its build and have a full flight system ready for delivery to our launch provider by summer 2023. We’ll be ready to go to the Moon!

As a small spacecraft, Lunar Trailblazer cannot do a direct burn and deceleration like the Apollo spacecraft. This is even though around two-thirds of Lunar Trailblazer's volume is its fuel tank. Instead, Lunar Trailblazer uses a low-energy transfer trajectory that is distinct for each and every launch date. It can take between 4-7mo to get to the Moon but it is a fuel efficient means of traveling.

Instruments

Lunar Trailblazer carries two instruments to achieve its science objectives: the High-resolution Volatiles and Minerals Moon Mapper (HVM3) from JPL, and the Lunar Thermal Mapper (LTM) from the University of Oxford. When used in conjunction, these two instruments provide the ability to simultaneously identify the various forms of water on the moon, mineralogy, and temperature.

HVM3

The High-resolution Volatiles and Minerals Moon Mapper (HVM3) instrument is a pushbroom shortwave infrared (SWIR) imaging spectrometer. With a spatial resolution of 70 m/pixel over a 20 km swath width, and a spectral resolution of 10 nm over a spectral range of 0.6 to 3.6 μm, HVM3 is optimized for the detection of volatiles to map OH, bound H2O, and water ice.

LTM

The Lunar Thermal Mapper (LTM) is a pushbroom multichannel imaging thermal radiometer. With a spatial resolution of 25 m/pixel over an 11 km swath width, 4 broad bands between 6 and 100 μm, and 11 bands between 7 and 10 μm, LTM simultaneously maps temperature (110-400 K), physical properties, and composition of water-bearing areas in HVM3 pixels.

Mission Phases

Lunar Trailblazer has not yet launched. Anticipated mission phases are listed below.   
  
Launch  
Lunar Trailblazer is anticipated to launch in Q4 of 2024.

Target Name: the Moon  
Mission Phase Start Time: Q4 of 2024  
Mission Phase Stop Time: Q4 of 2024

Cruise  
The cruise, lunar orbit insertion, and period reduction phases are estimated to last ~4-7 months, depending on when the spacecraft is launched.

Target Name: the Moon  
Mission Phase Start Time: Q4 of 2024  
Mission Phase Stop Time: TBD

Lunar Orbit Insertion  
Lunar orbit insertion follows the cruise phase.

Target Name: the Moon  
Mission Phase Start Time: TBD  
Mission Phase Stop Time: TBD

Period Reduction

Period reduction follows the lunar orbit insertion phase.

Target Name: the Moon  
Mission Phase Start Time: TBD  
Mission Phase Stop Time: TBD

Operations

Science operations follow the period reduction phase.

Target Name: the Moon  
Mission Phase Start Time: TBD  
Mission Phase Stop Time: TBD

Mission Objectives

From 2008 to 2010, a series of discoveries led to a surprising conclusion: there is water on the Moon! Water and other volatile elements were detected in lunar volcanic glasses, suggesting hydration of the mantle. Infrared spectrometers observed OH/H2O on the sunlit side of the Moon. The LCROSS impactor confirmed the presence of water ice in the permanently shadowed regions of the Moon. These findings now demand integration for understanding the history and evolution of volatiles on the Moon and throughout the inner solar system.

Sources of lunar water may include:

1. internal mantle water, present at formation and released by subsurface geologic processes
2. external water, delivered by asteroids and comets over lunar history
3. in situ, created on the surface by interactions with solar wind plasma.

Trailblazer places advanced infrared sensors in orbit for spatial and temporal characterization of water and cold traps. Our knowledge of the ‘lunar water cycle’ is in its infancy, and Trailblazer remote sensing is the next step to resolve current questions about the character and origin of water in the Earth-Moon system, and characterize resources for future landed exploration.

Lunar Trailblazer responds to some of the [major questions raised in the National Academies Decadal Surveys for Planetary Science](https://trailblazer.caltech.edu/news/decadalSurvey.html) from 2014-2023 and 2023-2032, including "How are volatiles distributed and transported on the Moon?" and "What are the inventories and origin of water on airless bodies?". Lunar Trailblazer also blazes a trail for human future exploration by evaluating "where are there operationally useful deposits of water?" and "what are the composition and thermophysical properties of the surface of future landing sites?". As a small, cost-constrained mission, Lunar Trailblazer is optimized to one focused science goal.

*Objective 1: Determine the form, abundance, and distribution of H2O and OH in sunlit terrains.*

Trailblazer will determine the form of water (OH vs. bound H2O vs. H2O ice), how much is present, and its distribution on the sunlit side of the Moon. A correlation between localized enhancements of water with silicic domes, pyroclastic glasses, and deeply sourced norites and anorthosites could suggest that the water is endogenic, providing a global assessment of which magmatic reservoirs are enriched in water, and whether they are correlated with other incompatible elements. These results would provide new information for understanding the thermal evolution of the Moon.

*Objective 2: Assess time variability of lunar volatiles.*

Prior measurements suggest that a portion of the water or hydrated products on the surface of the moon is time-dependent, implying active creation and destruction of chemical bonds. Such activity could be driven by solar processes and/or mobility of volatiles on the surface today, in response to thermal gradients. Trailblazer seeks to characterize modern temporal variability and its possible correlation with mineralogy and soil maturity.

*Objective 3: Determine the form and abundance of ice, bound H2O, and OH in permanently shadowed regions (PSRs)*

At the poles of the Moon are regions that are permanently in shadow, which have been hypothesized to contain water ice that could potentially host organic content. Understanding the amount of water ice present, its form, purity, and geologic and topographic context are crucial to understanding the role of these reservoirs in the lunar water cycle, or as resources for future explorers.

*Objective 4: Understand how localized gradients in albedo and surface temperature affect ice and OH/H2O concentration*

Possible co-variation of temperature and volatile type and abundance can help explain the behavior of lunar water and constrain the lifetime of ice deposits. In addition, the small-scale topography and surface thermophysical parameters may influence the properties of the water and its stability and accessibility. Trailblazer's spatially high-resolution temperature data will help determine how water cycles function on airless bodies.

*Bonus Science*

Exploration zone reconnaissance for landed missions and mapping crust lithologic composition.