NASA laser reflector for ESA satnav on Lunar Pathfinder

November 10 2022

Laser Retroreflector Array. Credit: SSTL

NASA has delivered a retroreflector array to ESA that will allow the Lunar Pathfinder mission to be pinpointed by laser ranging stations back on Earth as it orbits the moon. Such centimeter level laser measurements will serve as an independent check on the spacecraft as it fixes its position using Galleo and GPS signals from an unprecedented 400,000 km away from Earth—proving the concept of lunar satnav while also relaying telecommunications ahead of ESA's dedicated Moonlight initiative.

Safeguarded within multiple layers of packaging with "shock watches" in three dimensions within the shipping case, to detect any rough treatment, NASA's Laser Retroreflector Array, LRA, was successfully delivered to Surrey Satellite Technology Ltd, SSTL, in Guildford, U.K.

After unpacking and following the established procedures, a visual inspection of the LRA was jointly performed by ESA, NASA and SSTL, confirming there are no scratches and nicks in the optics. As a result, the instrument was formally accepted by ESA on November 4, 2022 and was passed to SSTL for integration aboard their washing-machine-sized spacecraft, which is due to be launched in 2025.

SSTL's Lunar Pathfinder will serve as a telecommunications relay satellite for future missions to the moon, with ESA as a core customer, while NASA will also make use of its services in exchange of delivering Lunar Pathfinder to lunar orbit through its Commercial Lunar Payload Services (CLPS) initiative.

"Today's delivery is an additional element of this unique ESA-NASA collaboration, which includes an in-orbit test campaign to demonstrate the use of satellite navigation signals in lunar orbit and laser ranging to authenticate these pioneering satnav positioning fixes," explains Javier Ventura-Traveset, leading ESA's Galileo Navigation Science Office and coordinating ESA lunar navigation activities.

Today, tracking a spacecraft in lunar orbit requires multiple ground stations to perform radio ranging. Lunar Pathfinder will employ a standard X-band transponder for this purpose, but in addition will carry ESA's NaviMoon Global Navigation Satellite System receiver.

Achieving position fixes from Galileo and GPS so far out in space requires clever engineering and signal processing techniques, because the signals extending out to lunar orbit are millions of times weaker than those we receive using our smartphones or cars. But success would mean future moon missions could effectively steer themselves—fixing their position automatically using GNSS better than 100m, an order of magnitude improvement over current radio ranging—while foregoing the use of costly ground infrastructure.

Javier adds, "Both ESA and NASA are highly interested in exploiting the LRA data with our NaviMoon satnav receiver, which will enable the cross-checking of positioning fixes across cislunar distance and open up new possibilities in lunar geodesy. These tests will also provide a very valuable technological learning for ESA's Moonlight initiative, which will provide before the end of this decade an autonomous network of communications and navigation satellites supporting lunar exploration."

Laser retroreflectors are well-established space technology, normally used to precisely determine the orbit of satellites around the Earth. By measuring the time of flight for the laser pulses to travel from Earth to the satellite and back, its precise distance can be calculated—along the same lines as radio-based ranging, but achieving much higher accuracy because of the short wavelength of light.

In approach they resemble the mirrored "cats eyes" embedded in motorways to reflect light precisely back to its source, thanks to an intricate internal reflection setup—a total of 48 "corner cubes" in the case of the LRA, which were individually and rigorously inspected and measured in the laboratory. The optical performance of the array was accurately measured at NASA's Goddard Space Flight Center.

About the size of a laptop, the LRA was produced for NASA by KBR, based on a previous LRA already flying on NASA's Lunar Reconnaissance Orbiter (LRO). Stephen Merkowitz, NASA's Space Geodesy Project Manager, states, "This LRA is larger and will return more than 12 times the laser light than the one on LRO since it has 48 corner cubes at 4 cm in diameter, compared to LRO's 12 reflector cubes at 3 cm in diameter. This opportunity is then rather unique."

Lunar Pathfinder will orbit in a highly elliptical "Lunar Frozen Orbit," designed to optimize coverage over the moon's South Pole, the primary focus of future exploration efforts. For this demonstration, the Lunar Pathfinder satellite will be reoriented in orbit, typically during a continuous five-day experimental window, so that the LRA, the NaviMoon receiver antenna and the X-Band transponder ranging, all located on the same panel of the satellite, together point towards Earth. This will maximize the attainable performances and the joint visibility of these three geodetic techniques, which will be used simultaneously for the first time ever in lunar orbit.

The International Laser Ranging Service currently has four stations capable of laser ranging out to lunar distance, three based in Europe (Grasse, Wetzel, and Matera) and one in the US (Apache Point). In addition, ESA is considering the use of its own Tenerife-based Laser Ranging Station, which is currently being upgraded.

As a next step, the LRA will undergo final inspection at SSTL before being integrated onto Lunar Pathfinder—having to be precisely fitted and aligned to maximize positioning accuracy.

Lily Forward, SSTL Lunar Pathfinder Systems Engineer, states, "This is SSTL's first piece of flight hardware for the Lunar Pathfinder and is the result of an excellent collaboration between ESA, NASA and SSTL. We are all eager to put this ranging experiment to the test once SSTL's Lunar

Pathfinder has launched."

Then, in the decade to come, dedicated Moonlight satellites and eventually additional hardware on the lunar surface will establish a common communications and navigation infrastructure for all lunar missions, effectively bringing the moon closer to Earth in practical terms, rendering it our planet's eighth continent.

Provided by European Space Agency

Citation: NASA laser reflector for ESA satnav on Lunar Pathfinder (2022, November 10) retrieved 2 May 2024 from https://phys.org/news/2022-11-nasa-laser-reflector-esa-satnav.html