Wireless power transmission could enable exploration of the far side of the moon

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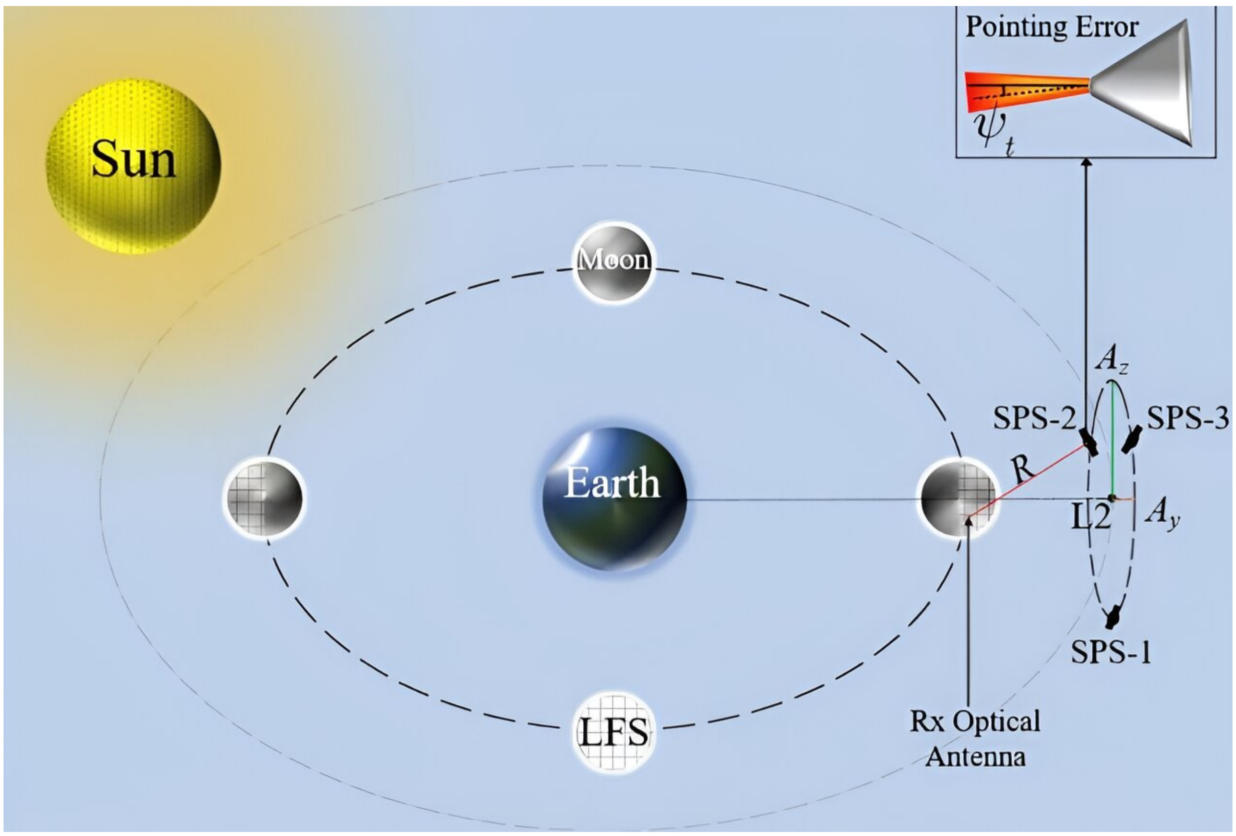

Schematic from Figure 1 of the study displaying the wireless power transmission and receiver on the lunar far side with three satellites (SPS-1, SPS-2, and SPS-3) in a halo orbit at the Earth-Moon Lagrange Point 2. Credit: Donmez & Kurt (2024)

How can future lunar exploration communicate from the far side of the moon despite never being inline with the Earth? This is what a recent study submitted to *IEEE Transactions on Aerospace and Electronic Systems* hopes to address as a pair of researchers from the Polytechnique Montréal investigated the potential for a wireless power transmission method (WPT) comprised of anywhere from one to three satellites located at Earth-moon Lagrange Point 2 (EMLP-2) and a solar-powered receiver on the far side of the moon.

This study, available on the *arXiv* preprint server, holds the potential to help scientists and future lunar astronauts maintain constant communication between the Earth and moon since the lunar far side of the moon is always facing away from Earth from the moon's rotation being almost entirely synced with its orbit around the Earth.

Here, Universe Today discusses this research with Dr. Gunes Karabulut Kurt, who is an associate professor at IEEE Polytechnique Montréal and the study's co-author, regarding the motivation behind the study, significant results, follow-up research, and implications for WPT. So, what was the motivation behind this study?

"This research is motivated by the objective of overcoming the logistical and technical challenges associated with using traditional cables on the moon's surface," Dr. Kurt tells Universe Today. "Laying cables on the moon's rough, dusty surface would lead to ongoing maintenance and wear problems, as lunar dust is highly abrasive. On the other hand, transporting large quantities of cables to the moon requires a significant amount of fuel, which adds considerably to the mission's costs."

For the study, the researchers used a myriad of calculations and computer models to ascertain if one, two, or three satellites are sufficient within an EMLP-2 halo orbit to maintain both constant coverage of the lunar far side (LFS) and line of sight with the Earth. For context, EMLP-2 is located on the far side of the moon with the halo orbit being perpendicular—or sideways—to the moon's orbit. The calculations involved in the study included the distances between each satellite, the antenna angles between the satellites and surface receiver, the amount of LFS surface coverage, and the amount of transmitted power between the satellites and LFS surface antennae. So, what were the most significant results from this study?

Dr. Kurt tells Universe Today their models concluded that three satellites in an EMLP-2 halo orbit and operating at equal distances from each other could "achieve continuous power beaming to a receiver optical antenna anywhere on the lunar far side" while maintaining 100 percent LFS coverage and line of sight with the Earth. "Aside triple satellite scheme that provides continuous LFS full coverage, even a two-satellite configuration provides full coverage during 88.60% of a full cycle around the EMLP-2 halo orbit," Dr. Kurt adds.

Regarding follow-up research, Dr. Kurt tells Universe Today, "Our future studies will focus on more complex harvesting and transmission models to get closer to reality. On the other hand, an approach that takes into account the irregular nature of lunar dust and the variation in its density due to environmental factors such as subsolar angle and others. In the future, if research in this field continues, explore this experimentally with lunar dust simulants and lasers."

This study comes as NASA is preparing to send astronauts to the moon for the first time since 1972 with the Artemis program, whose goal will be to land the first woman and person of color on the lunar surface. With the success of the Artemis 1 mission in November 2022 that consisted of an uncrewed Orion capsule orbiting the moon, NASA is currently targeting September 2025 for their Artemis 2 mission, which is scheduled to be a 10-day, 4-person crewed mission using the Orion capsule for a lunar flyby, whose goal will be to conduct a full systems checkout of the Orion capsule. Therefore, what implications can this study have for the upcoming Artemis missions, or any future human exploration of the moon?

"The findings have implications for the design of energy transmission systems on the moon," Dr. Kurt tells Universe Today. "A better understanding of the wireless transmission disruptors such as lunar dust can lead to the development of more efficient and reliable systems for powering lunar missions and infrastructure, including those related to the Artemis program and future human exploration efforts."

If successful, Artemis 2 will be followed by Artemis 3 in September 2026, which will also consist of a 4-person crew with two crew members landing on the lunar surface and an approximate mission duration of 30 days. This will be followed by Artemis 4, Artemis 5, and Artemis 6, which are currently scheduled for September 2028, September 2029, and September 2030, respectively, with each mission increasing in both the number of astronauts landing on the lunar surface along with anticipated deliveries of lunar habitat modules and lunar rovers, as well.

"Moreover, the Artemis mission is targeting the lunar south pole for its landing sites," Dr. Kurt tells Universe Today. "This region is of particular interest due to the presence of peaks of eternal light (PELs), which receive almost continuous sunlight and permanently shadowed regions (PSRs), which are potential sites for resources such as water ice. These contrasting conditions are ideal for the application of wireless energy transmission (laser power beaming technology), which could provide a continuous power supply in shadowed areas by transmitting energy wirelessly from illuminated regions."

The reason these PSRs exist is due to the moon's low obliquity, or axial tilt, which the study notes is 6.68 degrees. For context, the Earth's obliquity is 23.44 degrees. This means there are areas, and specifically craters, at both the north and south poles on the moon that do not receive any sunlight, hence the name "permanently shadowed regions." As noted by Dr. Kurt, these PSRs could be home to deposits of water ice within these deep, dark craters that astronauts could use for water, fuel, and other needs.

The Artemis missions plan to deliver not only astronauts to the lunar surface, but a habitat and lunar rovers with the goal of establishing a permanent human presence on the moon. This will provide opportunities for demonstrating new space technologies that can be used for both lunar exploration and future human missions to Mars, which are a part of NASA's moon to Mars Architecture.

"Current missions plan to re-use Earth-proven technology," Dr. Kurt tells Universe Today. "This mindset may undermine the blue-sky design approach, where researchers are encouraged to think freely, explore creative ideas, and push the boundaries of what's possible without being confined by constraints such as specific project requirements or backward compatibility. In our work we aim to include multi-functionality aspects, which are not a necessity for terrestrial applications but may turn out to be essential for future space missions."

More information: Baris Donmez et al, Continuous Power Beaming to Lunar Far Side from EMLP-2 Halo Orbit, *arXiv* (2024). DOI: 10.48550/arxiv.2402.16320

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