Building a lunar network using a long-lived, human-deployed Lunar Geophysical Package (LGP)

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Geophysical measurements address science goals outlined in The Scientific Context for Exploration of the Moon [1] and its recent progress report, Advancing Science of the Moon [2]. The Lunar Geophysical Package (LGP) is a long-lived surface package deployable by astronauts or by commercial landers, combining seismic, electromagnetic, heat flow and laser ranging measurements. The LGP would be a ready-to-go package that can be networked with other geophysical packages delivered by astronauts, or by commercial landers. A long-lived package like the LGP, or any other, similar long-lived geophysical deployment [e.g. 5] which can continue to make measurements for years through lunar day and night, well beyond the initial deployment mission, will be key to making long-term measurements like those that have given us our view of the interior of our own planet.

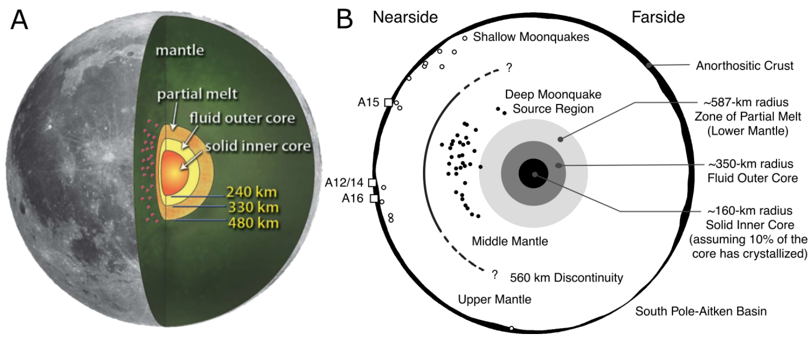

Figure 1. Geophysical measurements have illuminated the first-order internal structure of the Moon (A, from [3]) and significant lateral variation between the near and far sides of the Moon (B, from [4]), but significant questions remain about the size of the core, layering in the mantle, and lateral heterogeneity.

The importance of geophysical measurements was recognized in the Apollo era, and geophysical instruments were deployed as part of the Apollo Lunar Surface Experiments Package [6,7]. Re-examination of Apollo data and sample analyses combined with a wealth of new data from later missions have led to a general understanding of a crust [8], mantle, and core [3,9]. Despite recent advances, though, many questions remain (e.g. Figure 1). In particular, constraints on core composition and structure are poor resulting in large variations among current seismic models [10]; yet this deepest region of the Moon is key to understanding lunar evolution, including whether the Moon could have supported an early global dynamo [e.g. 11]. Questions also remain about discontinuities within the mantle, as well as the nature, depth extent, and thermal characteristics of the Procellarum KREEP Terrain [e.g. 12]. Local and global crustal thickness can be constrained from a combination of receiver functions [13,8] and an estimate of local seismic velocities. The GRAIL gravity model of crustal thickness [14] is tied to estimated thickness at Apollo 12. An additional data point would reduce uncertainty in the model.

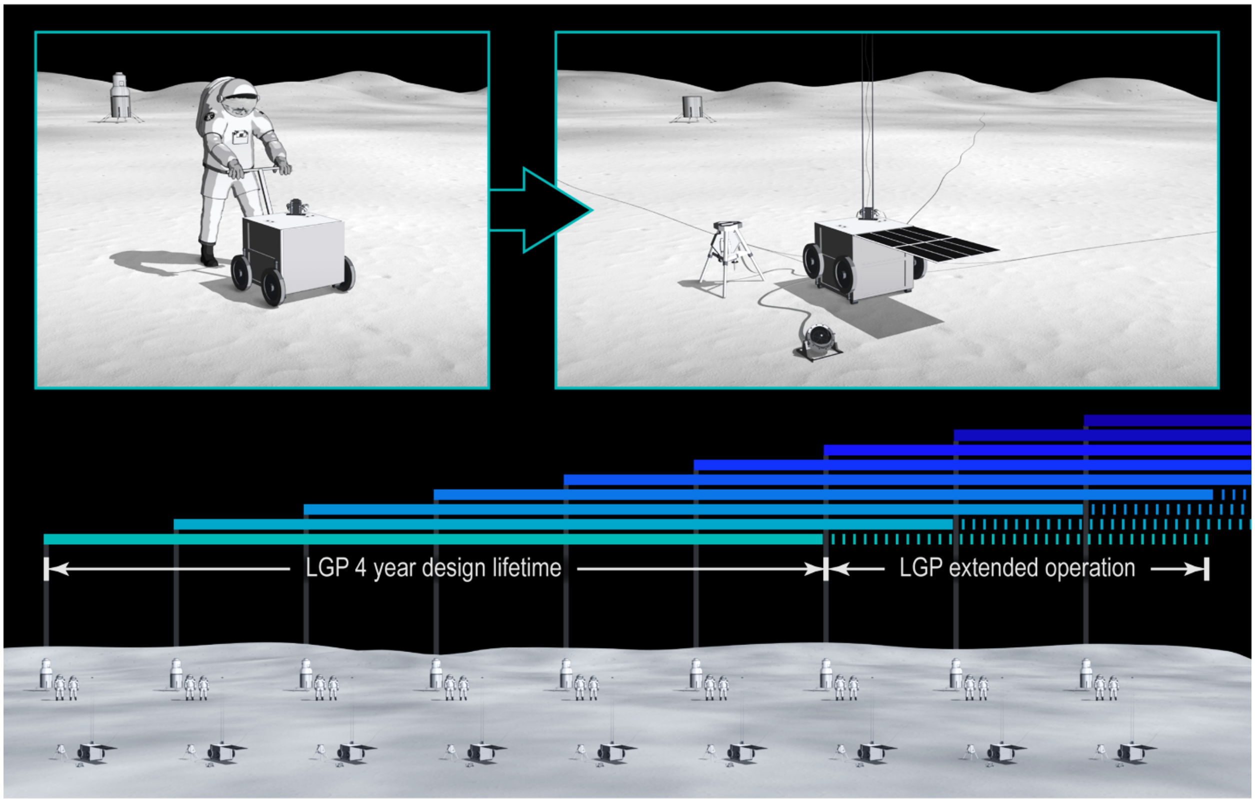

Figure 2. Astronauts wheel the LGP to desired site, and deploy payload elements (artist's concept, top). The package can be deployed at all Artemis sites and can be modified to fly on commercial landers as well.

LGP will address these questions by constraining the current seismic state and internal structure of the Moon, measuring its heat flow to characterize the temperature structure [15,16], installing a next-generation laser ranging capability to further constrain deep structure [17,18], and measuring the electrical conductivity of the lunar interior [19,20]. While the InSight mission has shown that some seismic objectives can be met with a single lander [21] and the other geophysical measurements are powerful from a single site, the lunar science community recognizes that a network would help fully address these objectives, prioritizing a Lunar Geophysical Network (LGN) as a New Frontiers Mission [22]. A long-lived node with multiple geophysical instruments like the LGP can begin reaching science goals in advance of a New Frontiers-level LGN by progressively building a network of nodes with overlapping lifetimes as well as complementing a New Frontiers-level LGN. The system is designed to be deployed by Artemis astronauts (Figure 2), but additional nodes could be distributed around the Moon by commercial landers.

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