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Introduction: The Lunar Environment Monitoring Station (LEMS) is an instrument concept funded by NASA's Development of Advanced Lunar Instrumentation Program, and undergoing maturation at the Goddard Space Flight Center's Planetary Environment Laboratory (PEL).

LEMS is a compact, autonomous, and self-sustaining instrument package that will enable long-term, in-situ, monitoring of the lunar exosphere. The Station will be capable of collecting daily in-situ measurements of exospheric composition for a nominal duration of 2 years from its deployment on the surface of the Moon. Additionally, the instrument package will accommodate an interferometric seismometer capable of continuously monitoring the Moon's seismic activities in order to constrain the structure of the lunar interior. At the end of its development, LEMS will be a flight-ready, opportunistic investigation that can be deployed by crewed lunar missions. Once delivered and deployed on the lunar surface, LEMS will require no additional support in order to operate.

Science Imperatives: The planetary community has recognized that solar system exploration must fill gaps in our knowledge concerning surface boundary exospheres, the most commonly found type of atmosphere in the solar system (surrounding e.g., asteroids, Mercury, and numerous moons). Likewise, planetary interiors remain largely unexplored, and seismology from Apollo gave us our first glimpse of the inner workings of the Moon. At the Moon, these tasks are of higher priority in light of the imminent restart of manned and unmanned lunar exploration for both scientific and commercial purposes.

For the exosphere, this renewed era of lunar exploration has the potential of overwhelming the natural environment of the Moon and displacing the balance of various reservoirs of volatiles. New long-lived seismic stations will advance Decadal science priorities while establishing hazards to future exploration missions. A strategy of long-term in-situ monitoring of the lunar exosphere is important for our understanding of the dynamics of surface boundary exospheres in general, and for determining the response of the lunar environment at various time scales to injections of exotic materials from natural or manmade events. This in-situ, long-term approach readily lends itself to concurrently monitoring the seismicity of the Moon as well.

Instrument Description: The LEMS station is comprised of three main elements: a Quadrupole Mass Spectrometer, an interferometric seismometer, and the Platform that provides power, thermal, and communication resources to the two sensors.

The mass spectrometer and its driving electronics are identical in heritage and design to those of LADEE/NMS [1] and MAVEN/NGIMS [2]. The seismometer, developed at the University of Arizona is based on a commercial rugged geophone [3]. The architecture of the Platform leverages substantial GSFC investments in smallsat/cubesat subsystems that can be easily modifiable for a variety of architectures and mission requirements.

LEMS deployment by crewed mission

To achieve the highest level of sensitivity and mitigate the effect of outgassing from nearby structures, the LEMS mass spectrometer needs to be placed at > 100 m from its delivery vehicle. Additionally, to maximize its sensitivity to seismic events, LEMS requires placement in direct contact with the lunar surface. A manual deployment by a crew best satisfies these two critical requirements.

Figure 1: LEMS all-in-one package

LEMS was optimized for easy manual deployment and to minimize the workload of future lunar astronauts. Its standalone easy-to-handle package does not require fine pointing or alignment during placement. Furthermore, it does not require electrical setting up. Once the astronauts clear the area, LEMS will be commanded remotely to deploy and begin its autonomous operation. Once placed on the surface, LEMS does not require any external electrical, thermal or communication resources

Table 1 summarizes the main characteristics of the LEMS system

Table 1: LEMS Specifications

Specification		Value
Station	Mass	30 kg
	Volume	30 cm × 45 cm × 22 cm
	Av. Avail. Power	30 W (self-powered)
	Avail. data rate	256 kbps (X band/DSN)
	Min. mission duration	2 years
Mass Spectrometer (Exosphere)	Mass range	2 – 150 amu
	Density range	$1 – 5 \times 10^{13}$ cm^3
	Measurement cadence	Daily
Seismometer (interior)	Sensitivity	10^{-8} $m/s^2/\sqrt{Hz}$ at 1 Hz
	Bandwidth	0.1 – 50 Hz
	Sampling rate	50 sample/s

References: [1] Mahaffy P. M. et al. (2014) *SSR, 185,* 27–61. [2] Mahaffy P. M. et al. (2015) *SSR, 195,* 4073. [3] Marusiak, A. G. et al. (2018) *AGU Fall Meeting 2018*, abstract #P42B-03.